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Management of Water Works

By Louis R. Howson

GOOD water works management does not just happen, it is created. It is the result of a combination of continuing policies with respect to expansion of both facilities and operations, sound financing, economical administration, and good service, all of which create good management as well as resulting from it.

It is not true that only a large water works plant can afford good management. No plant, however small, can afford not to have it. All too often we think of management as confined to the direction of the more or less routine operating functions. That is a very circumscribed definition. Good management of a water works property, like that of an individual, requires sound planning for the future and the co-ordination of needs with the financial ability to support them; it requires the development of a living routine which will carry through an orderly progression with adequate means so that the future will largely take care of itself. Also, with water works, as with individuals, good management may and frequently does include building by the present generation to provide for some of the requirements of those who are to follow.

The normal water works is a growing institution. There is really no such thing as a static one. It is going either forward or backward. With the public's growing appreciation of improved service, even a

A paper presented on April 24, 1941, at the Indiana Section Meeting, Indianapolis, Ind., by Louis R. Howson, Alvord, Burdick & Howson, Engineers, Chicago.

water works serving a city with little or no population growth is under the necessity of making expenditures for improved service which the public demands and is entitled to receive.

Need for Construction Program

Taken by and large, approximately $1.00 to $1.50 per capita is spent each year for new water works construction. That is the equivalent of from 10 to 25 per cent of the total water works revenue. The public does not like to be confronted at frequent intervals with bond issues to take care of expansion in facilities. It is, therefore, much more convenient (and incidentally much cheaper, for it costs only 60 per cent as much to finance improvements from revenues as by bond issues) to arrange the construction program so that financing may be done from current earnings. Such a program, however, is only practicable when expenditures for new construction are made at a relatively uniform rate; and that, in turn, can be done only when there is available a carefully prepared study of future requirements for a decade or two in advance and a distribution of the costs of construction incidental to meeting those requirements so as to iron out variations in expenditures for new construction, insofar as practicable.

A good construction program is one of the best deterrents to the raiding of the water works treasury. Sporadic construction, such as is usually undertaken in the absence of a carefully worked out construction program, accumulates surpluses in the treasury and invites raids during periods when no construction is going on. The best antidote for diversion of water works funds is a sound construction program as a result of which there is at no time a large, unexpended balance in the water works account.

Value of Well-Designed Rate Schedules

Rates as well as construction policies should be designed for future requirements. Once determined with reasonable equity they should be disturbed only rarely. Each adjustment in a rate schedule breeds a new crop of dissenters. As applied to public utility rates there is much truth in the old saying: "It won't get well as long as you pick it."

Few rate schedules are entirely equitable as between classes of consumers. Most schedules are a combination of strict equity and expediency. A reasonably equitable rate schedule in operation is better than a theoretically equitable one in the waste basket.

Just as there may be fewer truant children from homes of the better class, so is it easier to secure what is broadly termed "good management" under some kinds of environment than others. There are still many cities in which the water works management is directly under the city council, the personnel of which is continually shifting. In such a set-up, there is no centralized top responsibility; there are too many potential "bosses"; and the superintendent is always subject to change with the city administration. No one has any real concern about long-range planning for the work of later administrations. Politics are too prevalent and there is no centralized responsibility or continuing policy. While there are a few outstanding examples of good water works operation under city council form of government, that type of water works organization has, in general, been found difficult and relatively inefficient.

City Manager Control

In recent years there has been a growing tendency toward the city manager form of government. It is the writer's observation, with respect to this type of top management of water works property, that the management is only as good as the city manager. There have been numerous cases in which a city manager, in the belief that it was his responsibility to operate everything within the city, has disrupted a smoothly working water works organization in order to have all departments directly responsible to his office. Water works purchases have been consolidated with ordinary municipal purchases of ink, stamps, soap, fire hose, etc. Bookkeeping has been consolidated with that of the city treasurer's office, and in some cases, in order to "save expense," the city manager has dispensed with the services of an efficient executive trained in water works matters and has himself taken on that job with his other duties. As a result, the morale of the water works personnel has deteriorated, an efficient organization has disintegrated and, after a lapse of time, a deterioration in service has resulted. Water works management is a specialized experience in a most essential field. It cannot usually be successfully combined with other municipal operations.

A long observation of all types of water works management leads to the conclusion that the most satisfactory form of top management is that of a special commission, usually consisting of three to five men with overlapping terms of such lengths that no one political administration can upset the Board by a majority of new appointments.

Such a board is responsible to no one but the public which it serves. It is non-political; its continuity is assured; and it attracts to its membership the best qualified men of the community. Ordinarily the commission receives a little or no compensation other than the satisfaction of a job well done. Under such a form of management, it is found that continuity of employment is assured, efficiency is better maintained, constructive policies are formulated as to construction, operation and rates which continue without changing except as conditions warrant, and a maximum of service at a minimum of cost is furnished to the consumer.

It is believed that the water works profession will do much to improve its own status if it can effect a better top management. Certainly the most effective way to insure continuity of employment is through the operation of a non-political board.

Importance of Records

One of the essentials of good operation is, of course, that the operator have a complete, detailed knowledge of every operation of his plant, and, incidentally, a general knowledge of how those details compare with similar details of other plants. This can best be accomplished through a system of reports of which the manager himself is the greatest beneficiary.

Many years ago a man who had been an expert witness in a great deal of litigation stated that prior to going on the witness stand he always wrote the principal facts concerning which he was going to testify and on which he expected to be cross-examined in a little red notebook which he kept in his pocket. He seldom referred to that notebook during his examination but he held that the very fact that he had written in that book the principal facts so impressed them on his mind that they remained there.

Some of the most frequently observed "leaks" in management result from the lack of records or lack of familiarity with plant operating statistics. It is not unusual to find motor-driven centrifugal pumps operating under conditions so different from those for which they were designed that the excess power used in a few months will pay the cost of a new pump.

Every water works should set a par or a goal toward which it works. That should be set for each operation and lifted from time to time as improved operations catch up with the previous goal. One of the

largest water works operating companies has a "par" for each of its properties.

One of the most frequent evidences of deficient operation is that of the manner in which complaints are handled. There should be a record kept of every complaint, classified as to cause, location and how disposed of. There is no more reason why the complaint sheet should be discarded than that a sheet should be torn from the ledger or that there should be an unbalanced account.

These are but a few observations relative to management. It is hoped they will be sufficient to point out that good management begins with a full understanding of future requirements, the development of a sound construction program accompanied by a financial policy essential to their solution, both coupled with good economical administration which necessarily involves a knowledge of one's own plant in detail and in comparison with other plants similarly located and affected.

Emergency Radio Communication

By W. Victor Weir

IN PAST years few public water supply utilities have availed themselves of the advantages of radio communication, but in the future we can look forward to a much greater utilization of this important facility. The unlimited national emergency, recently declared, will lend impetus to the use of emergency radio communication. The organization of plans of action to go into effect upon the rise of emergencies in the water supply systems will cause the consideration and adoption of radio-telephone communication by many water departments.

Of the several general types of radio service now being employed, the public water supply industry's use of radio comes under the classification of "Emergency Radio Services," of the Federal Communications Commission (F.C.C.) rules and regulations. Emergency radio service, as defined there, means "a radio communication service carried on for emergency purposes." Four general types of stations are eligible for licenses under the emergency radio service category—police stations, marine fire stations, forestry stations and special emergency stations. Of these, the water works industry is interested in the police and the special emergency classifications, since the use of radio by water works must fall in one or the other of these classes.

Police radio service may be utilized to a limited extent, since "municipal police stations, although licensed primarily for communication with mobile police units, may transmit emergency messages to other mobile units, such as fire department vehicles, private ambulances, and repair units of public utilities, in those cases which require co-operation or co-ordination with police activities." (F.C.C. rules, 10.125.)

A paper presented on June 23, 1941, at the Toronto Convention, by W. Victor Weir, Superintendent, St. Louis County Water Company, University City, Mo.

F. C. C. Rules

Special emergency service is limited to use as follows:

"(a) Special emergency stations may be used *only during* an emergency jeopardizing life, *public safety*, or important property;

(1) for essential communications arising from the emergency;

(2) for emergency transmission from one point to another between which normal communication facilities do not exist, are not usable, or are temporarily disrupted or inadequate.

"(b) The use of special emergency stations for handling of routine or non-emergency communications is strictly prohibited.

"(c) Within the scope of service given in paragraph (a) the licensee of a special emergency station shall make the communication facilities of such station available to any member of the public.

"(d) Special emergency stations . . . shall not operate as common carriers of communications for hire. However, licensees of such stations may accept contributions to capital and operating expenses from others who, under the Commission's rules, would be eligible to stations of their own, for the co-operative use of the stations on a cost-sharing basis; *Provided*, that contracts for such co-operative use are submitted to the Commission 30 days prior to the effective date thereof and that said contracts are not disapproved by the Commission." (F.C.C. rules, 10.231.)

The water works use of radio is therefore strictly limited to emergencies or to communication between isolated points where telephone facilities do not exist. Sub-paragraph (b) quoted above should be particularly noted, since it definitely eliminates any possibility of routine dispatching through these channels of communication.

Emergency Use by Water Works

The majority of water supply emergencies arise in the distribution system, and are caused by broken mains, broken fire hydrants, and large fires. The simplest way of obtaining radio service in such emergencies is by the utilization of local municipal police radio stations to contact crews in the field. The field crews may be given instructions to proceed to the site of the emergency or may merely be instructed to telephone their office for instructions. This type of service is now being rendered in a number of cities. Since over 1,100 municipal police radio stations are now licensed, water depart-

ments in most large and medium sized cities could avail themselves of this service. The additional load placed upon the police station would be small. In most cases only the purchase of a few mobile receiving sets for installation on the water department emergency trucks would be involved.

Another type of emergency requiring the use of radio communication is the failure of the telephone lines between the city and the water plant, or between the plant and a distance intake or reservoir. Such emergencies ordinarily call for two-way communication under licenses for special emergency stations. The extended conversations often required during such emergencies could not be handled by the police radio station.

The ideal type of radio installation would be a transmitter-receiver at the water works office, with mobile transmitter-receivers on the essential maintenance trucks, and with transmitter-receiver installations at the outlying plants, to be utilized in case of telephone line failure. Such an installation would allow two-way communication covering practically any emergency which might arise. The cost of such a service might be lowered by installing a co-operative station with other utilities, such as electric and telephone, as allowed under sub-paragraph (d) above.

The Nov. 1, 1940, F.C.C. list of special emergency stations includes only 5 stations owned by 3 water departments as compared with 97 stations owned by 20 telephone and telegraph companies and 77 stations owned by 27 electric companies.

The Little Rock, Arkansas, water department has a radio station at the filter plant in the city and another at the Alum Fork dam, 35 miles west of the city. Radio communication between those two points is resorted to when telephone service is interrupted. The installation employs 100-watt transmitters operating on a frequency of 39,860 kilocycles. The Buffalo, N. Y., Water Department uses two 15-watt stations operating on a frequency of 39,660 kc. for communicating with the water intake pier located about $1\frac{1}{4}$ miles off shore in Lake Erie. The Beaumont, Tex., Water Department has one 50-watt station, at 2,726 kc., located on the Neches River.

Frequencies Available

Fourteen frequencies are available for emergency radio transmission, four in the medium high frequency band (2,292 to 4,637.5 kc.), of which three are for voice (A3), and ten in the ultra high frequency band (31,460 to 39,860 kc.), of which seven are for portable-mobile

stations with low maximum power, the remaining three being available for land or portable mobile stations without limitation as to power.

The first choice of frequency, therefore, is between the medium and ultra high frequency bands. Where it is possible to obtain good antenna location, ultra high frequency transmission will be the most desirable because of less interference from distant stations, greater uniformity of day and night range, less static interference, and the possibility of satisfactory two-way conversation with mobile units. If ultra high frequency is selected, the choice between 31,460 kc., 39,660 kc., and 39,860 kc., should be the frequency which will interfere the least with nearby emergency stations. All fixed or land ultra high frequency special emergency stations in the country must share these three frequencies.

Two Types of Modulation

Two general types of radio communication equipment are available, amplitude modulated (AM) or frequency modulated (FM) equipment. The AM equipment is the type now generally in use for all types of voice broadcasting. The FM equipment is a development of the last few years and offers certain advantages over AM equipment in the ultra high frequency range usually used for emergency communication, the main one being that receiver noise caused by interference from natural and man-made static is reduced, allowing clearer radio signal reception. Because of this noise reduction, FM transmission can be received over greater distances than AM transmission, the power being the same; or, for the same power and area to be covered, the FM transmission produces better intelligibility and tends to eliminate certain noisy "dead spots" where reception is difficult. As an example, using 25-watt transmitters and 100-foot antennas, transmitting to mobile receivers, the average range of AM equipment was reported to be six miles compared with fourteen miles for FM equipment. Using 250-watt transmitters and 200-foot antennas, the average range for AM equipment was fifteen miles as compared with thirty-three miles for FM equipment. The effectiveness of a 25-watt FM transmitter, then, is comparable to that of a 250-watt AM transmitter.

Where new transmitting equipment is to be purchased, FM will be offered by most manufacturers. Where it is necessary to purchase only receivers for use with existing police radio, the receivers must necessarily have the same type of modulation as the police equipment.

Equipment Available

Due to the large number of manufacturers, a considerable selection of radio equipment is available. Station arrangements, however, are very similar. A fixed or land headquarters station would probably have a transmitter of 25 or 50 watts, or, if more power were necessary, a 25- to 50-watt set would be used as the exciter for, for instance, a 250-watt power amplifier. The fixed station transmitter would be equipped with a power pack, taking its supply from 110–120 volt, 60 cycle, alternating current power line. Should this station be subject to a.c. power failure, the emergency power supply could be a dynamotor or vibrating inverter which would convert d.c. power from a standby battery to 115-volt a.c., or it could be a small gasoline motor-driven a.c. generator. The transmitter must be located near the antenna, and connected to it be means of gas-filled transmission cable. Should the antenna have to be located some distance from headquarters in order to obtain proper elevation, the transmitter may be connected to the headquarters office by means of telephone wires. In the office would be a remote-control unit containing a low level microphone pre-amplifier, push-to-talk button, and indicating lights for the distant transmitter.

The antenna and its location are very important in ultra high frequency transmission. Best reception is obtained when the transmitting antenna is high enough to permit line-of-sight transmission to the receiving antennas anywhere in the area to be covered. Where the receivers are mobile units, the transmitting antenna should, if possible, be located on the highest hill or building available. The antenna will be a quarter- or half-wave coaxial antenna, light in weight, mounted on a pipe supported from a tower, building or water tank.

Where two-way radio communication is installed, the fixed station receiver will be supplied with a.c. power. The receiver will obtain its signals from the same antenna as is used by the transmitter, unless the area covered is beyond the transmission range of the mobile units, as is possible in very large distribution systems. Remote antennas can be located at several points in the area covered, the signals being relayed to headquarters over telephone wires.

Mobile transmitters and receivers will obtain their power from the automobile battery, which, with the generator, must be heavier than standard equipment. The 6-volt battery power will operate a dynamotor or vibrator to supply the high voltage plate power. The mobile

antenna will be a whip antenna, one-quarter-wave or approximately seven feet long, for use in the 30 to 40 mc. range.

All modern receivers are equipped with "squelch" or noise-suppression devices which keep the receivers quiet except when they are receiving a radio signal of a pre-determined strength. Transmitter microphones are normally equipped with push-to-talk buttons, although voice operated control can be obtained. Depressing the push-to-talk button causes the transmitter to go from standby to transmission readiness, increasing the power drain from approximately 3 to 25 amperes for a 6-volt mobile transmitter of 25-watt output, or from 50 watts to 200 watts for a 115-volt transmitter of the same power.

Equipment can also be obtained to allow selective calling of desired receivers from headquarters. With this equipment it is possible to call to any desired receiver or to a selected group of receivers, all other receivers remaining inoperative. With this equipment in use, the receiver or receivers called can in turn operate a light, buzzer, bell or horn signal to call the receiving operator who may be working some distance away from his mobile unit. This device allows men not concerned with the message to continue with their work instead of returning to their cars to ascertain for whom the message is intended.

Cost of Equipment

Cost of radio communication equipment will vary to some extent, depending upon the manufacturers contacted and the amount of equipment to be purchased. For estimating purposes present day costs may be approximated as follows for FM ultra high frequency equipment: 250-watt station transmitter (necessary only for very large systems), $2,000; 25-watt station transmitter, $325; 25-watt mobile transmitter, $275; station or mobile receivers, $200; $\frac{1}{2}$-wave station antenna $75; $\frac{1}{4}$-wave mobile antenna, $15; $\frac{3}{8}$-inch gas-filled feed line, $0.40 per foot; $\frac{7}{8}$-inch gas-filled feed line, $0.75 per foot. The $\frac{3}{8}$-inch feed line will handle station transmitters with an output not exceeding 50 watts.

Qualification of Operators

The F.C.C. requirements regarding operators' qualifications may be summed up quickly by quoting from correspondence of T. J. Slowie, Secretary of the Commission, as follows: "Personnel holding at least

restricted radio-telephone operator permits may be employed at the land stations, if only A3 (voice) emission is requested and used. Likewise, the holders of at least restricted radio-telephone operator permits must be employed in the portable-mobile units when in operation, unless there is on duty at the associated land station, at all times, an operator who holds a second, or higher, class license, who has complete authority over the portable-mobile units and the personnel therein. This permit does not require a knowledge of technical questions on radio but requires a knowledge of law, rules, and regulations together with the Treaty Provisions with which every radio operator should be familiar. However, service and maintenance of the transmitting equipment may be conducted only by personnel holding second class radio operator licenses or higher. In the interest of continuity of service, if such an operator is not regularly employed at the radio station he should be immediately available." In view of the large number of emergency stations now in operation, water departments should have little difficulty in qualifying operators.

Procedure of Adoption

When a decision has been reached to investigate the feasibility of utilizing emergency radio communication in any water works system, the first step should be to ascertain whether any existing emergency station can be utilized on a co-operative basis. If so, the operator of that station should be consulted regarding the equipment necessary to outfit the desired water works units. If no existing service is available, the simplest beginning procedure would be to call in representatives of various manufacturers, outline to them the service desired, the area to be covered, and if possible be ready to furnish data on the topography to be encountered, power available, and emergency power if necessary. The equipment manufacturer will usually obtain the necessary station permit forms, assist in their preparation, and will also assist in the matter of operators' qualifications.

Applications to the F.C.C. must be filed in duplicate, one set for each land station and one set for the number of portable-mobile units to be associated with an individual land station, if their transmitters are identical. The applicant will be required to make a satisfactory showing that the use of radio is essential to the safety of life and property.

To assist water works operators in contacting manufacturers in the radio field, which has heretofore been a field strange to them, the following, necessarily incomplete, list of manufacturers is given:

Doolittle Radio, Inc.	Chicago, Ill.
Fred M. Link	New York, N. Y.
Galvin Mfg. Corp.	Chicago, Ill.
Gamewell Co.	Newton, Mass.
General Electric Co.	Schenectady, N. Y.
Harvey Radio Labs., Inc.	Cambridge, Mass.
RCA Mfg. Co., Inc.	Camden, N. J.
Technical Radio, Inc.	San Francisco, Calif.
Western Electric Co.	New York, N. Y.
Westinghouse Electric & Mfg. Co.	Chicopee Falls, Mass.

Discussion by *W. W. Hurlbut.* * The Department of Water and Power of the City of Los Angeles is the licensee of eight radio stations covered by nine licenses, one station being dually licensed. Stations are located at Los Angeles, Independence, Victorville Switching Station, Silver Lake Switching Station, Boulder City, and on board the launch Betty S. Two station licenses are for portable stations which are held at Los Angeles ready for service and may be moved to any point not covered by the fixed licenses, in order to meet special or emergency communication needs.

At the present time, the Department considers radio to be an auxiliary or reinforcement to its regular channels of communication such as telephone, telegraph, carrier current telephone, etc., over the long distances between remote points on the system. The stations are intended primarily for use during serious emergency, which is in accordance with the Federal Communications Commission's "Rules and Regulations," governing the operation of special emergency stations. Aside from the boat transmitter, all equipment is of the type used in stationary operation, the Department having no license as yet for mobile use. The Department has a staff of licensed radio telegraph operators whose duties cover the routine testing and maintenance of the transmitters. In some cases, this does not require full-time work and the radio operators are used on closely related work such as maintenance of equipment, operation of telegraph and teletype circuits, radio interference investigation, and kindred activities.

Studies are in progress to determine the feasibility and manner of adaptation of voice radio communication to emergency field crews for the purpose of restoring both water and power services in the event of unforeseen disruptions. Under the Federal regulations,

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routine dispatching by radio is not permissible. Broken water mains or power lines, however, constitute an emergency condition which is dangerous from the standpoint of public welfare. As radio offers the only method of communication to repair trucks which are away from their bases, it seems apparent, from past experience with other utilities, that the F.C.C. recognizes this as justification for the issuance of licenses.

The F.C.C. issues its "Rules and Regulations" in booklet form by chapters, which are available at low cost from the Superintendent of Documents, Washington, D. C. Special emergency operation, such as required by the Commission for utilities, is covered by Part 10, Chapter I, Title 47, Telecommunication, "Rules and Regulations," Federal Communications Commission. The price is five cents per copy.

The Department obtained its first special emergency licenses in 1927, covering installations in Los Angeles and the Owens Valley, where the station was first located at Lone Pine and later moved to Independence. A-1, or radio telegraph, emission has been used in the past, principally due to technical reasons, the most important of which is distance. On several occasions, due to storm, flood and social disturbances, radio has presented the only method of communication between remote points along the system.

Reforestation of Ohio Water Works Properties

By T. R. Lathrop

REFORESTATION of waste lands is really a problem for the state or Federal government. When the profit motive alone is considered, the average individual cannot be interested in investment of funds where financial returns from them cannot be expected sooner than 50 years from the date of investment; and good timber will require perhaps twice that period for growth. When consideration must be given to taxes on the land and upkeep of the forest—protection from fire, disease, etc.—during such a period, one can see the necessity of a continuity of interest in the project beyond that which the individual can provide. On the other hand, forests owned by a few municipalities have been developed and are a success financially. European municipal forests have been very successful, but this has been largely a result of the different economic status of the people. The removal of dead and diseased timber from a European forest is no problem, for in Europe there is a continual demand for firewood.

The planting and care of a forest adjacent to the average small water supply reservoir will probably never be financially profitable, although, where relatively large areas are involved, it is possible that in time enough lumber will be produced to make the project economically feasible. Under these conditions it may be wondered why the planting of forest trees on reservoir watersheds is advocated. Actually several reasons have prompted such a recommendation:

1. A growing crop improves the property.

2. Pine and spruce trees planted near the edge of reservoirs prevent leaves of deciduous trees from blowing into the water where they cause color and promote taste and odor problems.

A paper presented on May 15, 1941, at the Ohio Section Meeting, Cincinnati, Ohio, by T. R. Lathrop, Assistant Engineer, State Department of Health, Columbus, Ohio.

3. Trees prevent soil erosion on the area planted and so reduce turbidity.

4. A forest provides attractive recreational areas.

5. In time, a forest may provide a profitable timber crop.

6. Owners of waste or unproductive land are thereby stimulated to plant such land to forest trees.

7. Such reforestation can change desolate areas into beautiful ones. A reservoir surrounded by pine forests may compare favorably with a well-landscaped estate.

Costs of Reforestation

The actual cost of trees, if purchased from a state forest nursery, is about $3 per thousand, in addition to which the cost of planting, if the trees are set on a permanent location, is about the same. When trees are purchased and reset in a nursery and cared for, for a year or two before final planting, the cost becomes considerably higher, but, although this method is often recommended, the additional expense involved is not, to the author's mind, always justified. In the end it seems less expensive to pay a little more for larger trees which may be planted immediately on their final location. Another expense which does not seem warranted, except under unusual conditions, is that of clearing weeds and brush away from trees for the first three or four years after planting. Even dispensing with such additional burdens, however, the simple planting of an area, at a total cost of $6 per thousand, involves more than just sitting back for from 50 to 100 years and then setting up a saw mill to reap a few hundred times the original investment. Several complicating factors may enter into the picture during that time:

1. A certain amount of loss during the first year or two will be sustained due to weather conditions and other such factors. A 90-per cent survival is excellent even under good weather conditions. A 60-per cent survival is what the Mahoning Valley Sanitary District has averaged over the past ten years of planting.

2. Forest fires will take their toll unless extreme care is effected.

3. Many trees are damaged by disease and insects so that they either die or are spoiled for use as lumber.

4. A large percentage of any planting of trees become overgrown by the more vigorous trees and die from lack of sunlight. These dead trees and dead underbranches must be removed if the danger from

fire is to be minimized. By harvest time the 1,000 trees originally in the stand are reduced to a marketable timber crop of perhaps 200.

5. Plantings near highways are subject to some thievery, both for landscaping purposes and for Christmas trees. (It is advisable to plant spruce trees well back from the highway because of their attractiveness as Christmas trees.)

Reforestation in Ohio

In the Eastern states several water works properties initiated reforestation programs several years ago. The reservoirs of New York City are surrounded by pine forests. The water works at York, Pa., has extensive forest plantings, now many years old, and the Federal Water Service Co. has made extensive plantings around its reservoirs in northeastern Pennsylvania. The first forest planting on a reservoir site in Ohio was started at Akron in 1924, and this is the largest Ohio municipal forest, including 2,300 acres in native forest, 600 acres planted with 500,000 trees and 2,400 acres to be planted. Over 500,000 trees are in nursery rows and will be planted during the next two or three years.

The Mahoning Valley Sanitary District has, from 1931 to 1941, made the largest planting in the state, having planted 4,350,000 trees of which 200,000 are hardwoods and the remainder pine and spruce. Of these, as disclosed by a recent survey by the State Forester, approximately 60 per cent have survived. Only 100 acres remain to be planted.

Barberton, Ohio, with 350,000 trees planted and 400 acres still to plant, is next in the size of program. The original plantings were begun in 1927 by a previous administration, but changes in administration have resulted in an even greater interest in the forest. The Barberton forest, situated along two highways, presents a most pleasing appearance to the public and the sustained interest by public officials is not surprising.

In Columbus, Ohio, 234,000 pine trees have been planted on the west side of the reservoirs, while the other side has been developed as a part of the park system, the landscaping of this area including the planting of 25,000 ornamentals.

Other Ohio municipal water works reservoirs where smaller plantings have been made are Swanton, where 35 acres, owned by the water works, are entirely planted; Bucyrus, Caldwell, Wellington,

Crooksville, Barnesville, Norwalk and Wellston—each with from 5 to 30 acres planted; and Wellsville, where no planting has been done, but where the water works property, about 75 acres in area, is almost completely covered with a beautiful forest consisting largely of hemlock trees.

The present status of reforestation by Ohio water works, then, may be summarized as: 3,600 acres planted, 2,800 acres of native forest and more than 3,000 acres still available for planting. These forests, while in themselves of no great economic importance as far as the state is concerned, are valuable to the water works man. In addition, they constitute an example of the feasibility of growing timber which, in time, should have a marked effect on the attitude of public officials toward giving support to the development of the millions of acres of submarginal land by both national and state forest projects. Some land in Ohio costs the state more in upkeep than is being returned in taxes. If this land could be taken out of so-called cultivation and put into forests, the relief load would be simplified and a future return would be assured.

Inhibition of Lead Corrosion With Sodium Hexametaphosphate

By G. B. Hatch

THE application of sodium hexametaphosphate,* in concentrations of 0.5 to 10.0 p.p.m., to municipal as well as industrial water supplies for the control of the corrosion of ferrous metals has been discussed previously by a number of writers (1, 2, 3, 4, 5). It has been suggested that this inhibitive action is due to an adsorbed film of metaphosphate, or some complex thereof, upon the metal or metal oxide surface (2). In view of the evidence of a similar adsorption on numerous other metals and their compounds (6), it appeared quite probable that the inhibitive action of metaphosphate upon corrosion would not be limited to iron and steel and, as a result, tests for the quantitative evaluation of the effect of these low concentrations of metaphosphate upon the corrosion of a number of non-ferrous metals were contemplated. Of these proposed investigations, that on lead has been completed and is to be described here. It was felt by the author that, because of the serious physiological aspect, i.e., the lead carried into the water, of the corrosion of this metal, its investigation was of primary importance.

Since the factor of prime interest in the corrosive attack upon lead is the total amount of the metal carried into the water, rather than the pitting, tuberculation or destruction of the metal itself, it was this quantity which was measured in the investigation described. The effect of metaphosphate upon the lead pick-up was determined at pH values ranging from 5.2 to 8.9; and measurements of the pick-up which resulted upon continuous passage of water through lead wool and through lead tubing were made. In the latter case, the increase in the lead content of water after standing for 24 hr. in the tubing was also determined.

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* Hereinafter referred to as *metaphosphate*.

Procedure of Tests

A series of tests was conducted in which the increase in lead concentration resulting from the passage of water through a column of lead wool, and the effect of application of a dose of 2 p.p.m. metaphosphate to this water were determined. The apparatus employed in these tests (Fig. 1) was identical with that used for the measure-

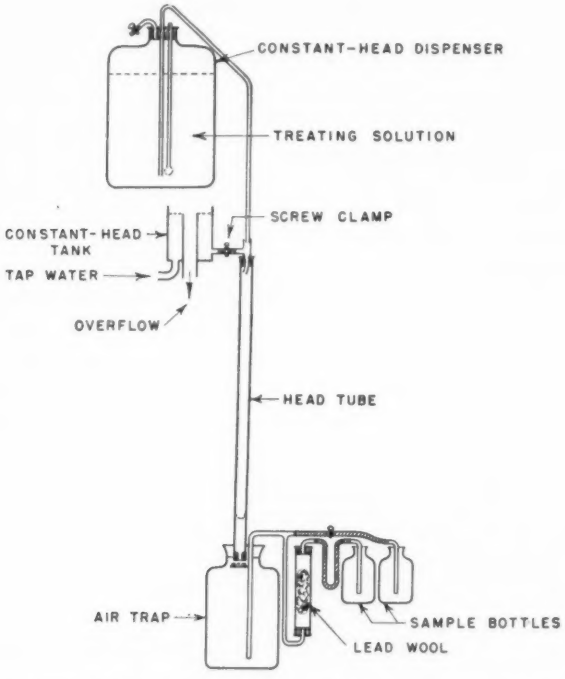

FIG. 1. Continuous-Flow Apparatus for Measurement of Corrosion of Lead Wool

ment of the corrosion of steel wool (2). Water at a rate of 500 ml. per min. was passed through a column of 120 grams of lead wool, packed into a $1\frac{1}{4}$-inch diameter glass tube in such a manner as to give a column 6 in. long. The lead wool in this tube was washed with acetone immediately prior to its use, and the lead content of the influent and effluent was determined by extractive titration with dithizone (7), the difference in the two values representing the lead pick-up.

The surface area of the quantity (120 grams) of lead wool used in the tests, calculated from microscopical measurements of the average cross-sectional dimensions of the individual strands, was 269 sq.in. (2), equivalent to the internal area of 19.6 ft. of $\frac{1}{4}$-inch standard pipe. The effect of a 2-p.p.m. dose of metaphosphate upon the pick-up in lead from the wool was determined at pH 5.2, 6.0, 7.0, and 8.9. The pH of the water supply, at the time of the tests, was 6.0; the lower

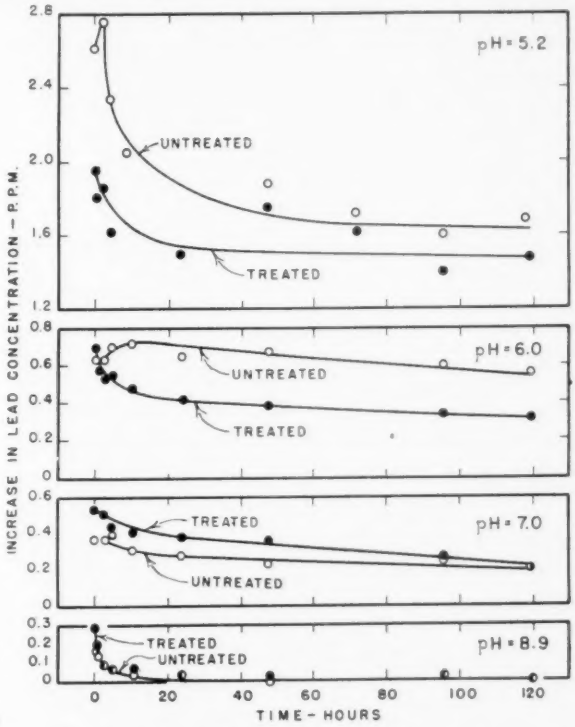

FIG. 2. Influence of Dosing With 2 p.p.m. Metaphosphate Upon the Increase in Lead Concentration, when waters at several pH values are passed through lead wool

value (5.2) was obtained by treatment of the original water with hydrochloric acid and the two higher values (7.0 and 8.9) by treatment with sodium carbonate.

The results obtained from the tests are given in Fig. 2, and the average analyses of the water supply during the course of the tests, in Table 1. In view of the relatively slight variation in the analyses during the tests, only the average values are included in the table.

Examination of Fig. 2 indicates that at pH 5.2 and 6.0 the presence of 2 p.p.m. metaphosphate inhibits the corrosion of lead. This inhibition is considerably more marked at pH 6.0 than at 5.2. The curve for the untreated water at pH 5.2 shows an initial decrease, probably the result of the formation of a sulfate film; at pH 6.0 the curve of the untreated water shows an initial inflection, apparently due to the destruction of the film originally present upon the lead surface, which is followed by a rather gradual drop, indicating the formation of a new protective film. In the presence of the metaphosphate, a rather sharp drop in the amount of dissolved lead in the initial portions of the curves at pH 5.2 and 6.0 is followed by a more gradual decrease. The initial drop appears to indicate the formation of a protective film due to the action of the metaphosphate; the succeeding

TABLE 1

Average Analyses of Water Supply During Corrosion Tests

ITEM	DURING TESTS OF FIG. 2	DURING TESTS OF FIG. 3
Temperature, *°C.*	28	17
pH	6.0	6.0
Oxygen, *p.p.m.*	—	8.4
Chloride, *p.p.m.*	22	14
Sulfate, *p.p.m.*	162	62
Calcium, *p.p.m.*	35	22
Magnesium, *p.p.m.*	8	2
Total hardness, *p.p.m.* $CaCO_3$	120	54
Total alkalinity, *p.p.m.* $CaCO_3$	3	7
Total solids, *p.p.m.*	268	142

gradual decrease is probably the result of the formation of a protective film such as formed in the untreated water, together with continued film formation due to the metaphosphate.

At pH 7.0, the curve for the untreated water decreases gradually, indicating that the protective coating, probably basic lead carbonate, attains its full efficacy quite slowly. The curve for the treated water lies above that for the untreated, indicating that the metaphosphate retards the rate of formation of the protective basic carbonate coating at this pH. In the latter portions of the curves, however, the lead pick-up decreases more rapidly in the case of the treated than of the untreated water, indicating that the effect of the metaphosphate is to retard, but not to prevent, the formation of the same protective film which forms in the untreated water.

At pH 8.9 the concentration of dissolved lead drops off quite rapidly in the untreated water until a very low constant value is attained. In the presence of the metaphosphate, the dissolved lead concentration drops off at a rate only slightly less rapid than is the case with the untreated water, the same low constant value being attained both in the presence and absence of the metaphosphate. The retardation of the formation of the protective coating at pH 8.9 as a result of the presence of metaphosphate is much less than at pH 7.0, probably because the tendency to form this coating is greater at the higher pH. At the two higher pH values, 7.0 and 8.9, the existence of a protective film due to the metaphosphate, if such does exist in this range, is masked by the greater protective action of the basic lead carbonate film.

Tests were also conducted with 4 p.p.m. metaphosphate at pH 6.0 with results that were practically the same as those obtained with the smaller dose, except that the initial drop in the dissolved lead concentration occurred a little more rapidly.

Lead Tubing Tests

In the case of lead wool corrosion tests the pick-up is apt to exceed that which would be experienced in a pipe of similar area, as a result of the closer proximity of the entire body of water to the lead surface upon passage through the wool than through the pipe. Moreover, with intermittent flow, the quantities of corrosion products which are dislodged from the wool and from the pipe are apt to differ considerably. Since the lead pick-up under conditions of intermittent flow in a pipe is of considerable importance from the point of view of its physiological effects, tests of this nature also were conducted.

The apparatus employed for the determination of the effect of a dose of 2 p.p.m. of metaphosphate upon the pick-up of lead from lead tubing was very similar to that shown in Fig. 1. The tube which contained the lead wool was replaced by 9 ft. of $\frac{1}{4}$-inch lead tubing wound in a coil $2\frac{1}{2}$ in. in diameter with its axis vertical. This coil was cleaned with acetone immediately prior to use. Water at a rate of 500 ml. per min. was then passed upward through the tubing, with occasional sampling of the effluent. At intervals the flow was discontinued and the water allowed to stand for 24 hr. in the coil, after which time it was drained into a sampling flask. The increases in lead concentrations in both the flowing and the 24-hour stagnant samples were measured.

The data obtained in these tests are shown in Fig. 3, average water analyses during the course of the tests being included in Table 1. The figure shows that, for the flowing water, the lead pick-up by the treated water runs consistently somewhat lower than for the untreated. In the case of 24-hour stagnant samples, the inhibitive action of the metaphosphate is considerably more marked. Even at the start of the tests, when only sufficient water had passed the

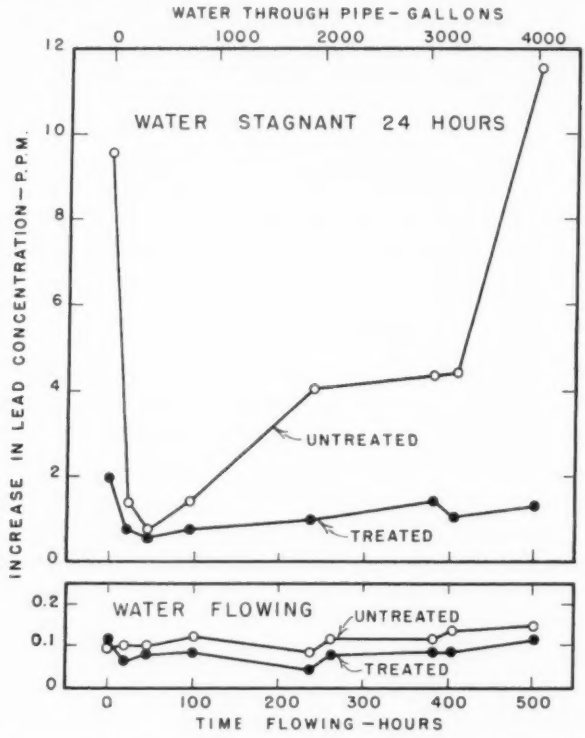

FIG. 3. Influence of Dosing With 2 p.p.m. Metaphosphate Upon the Increase in Lead Concentration, when water is allowed to stand in lead tubing and when it is passed through lead tubing

coils to insure removal of the acetone which had been used in the cleaning process, this inhibitive action upon the pick-up of lead by the stagnant water is apparent. This is somewhat surprising in view of the very small amount of metaphosphate, approximately 1 mg., to which the lead surface had been exposed.

The first three values for lead pick-up by untreated water, stagnant for 24 hr., show evidence of the formation of a protective film upon

the lead surface, but the subsequent values are higher. Visual examinations of these samples gave an indication of the cause of this apparently anomalous behavior. The first sample of untreated water removed after standing 24 hr. in the lead pipe was quite cloudy and appeared to contain minute dispersed crystals; the second sample was less turbid, and the third sample was clear. In subsequent samples the turbidity again increased. It appears that this crystalline phase first forms a somewhat protective layer upon the lead surface, but that this layer is rather poorly adherent and as it grows in thickness tends to flake off rather readily, particularly when flow is interrupted, or resumed after interruption.

In the case of the water treated with metaphosphate, the pick-up of lead by water stagnant for 24 hr. is considerably lower and more consistent than with the untreated water. None of the samples from this treated water gave the appearance of containing dispersed crystals.

At the conclusion of the above tests with lead tubing, the tubes were cut open and examined. The tubing which had been exposed to the untreated water showed a rather streaked and mottled appearance, while that which had been exposed to the treated water exhibited a much more uniform surface. Viewed under a microscope, the sections from the untreated water line showed numerous minute tubercles and spots of apparently bare metal; those from the treated water line showed far fewer tubercles and bare spots, the greater portion of the surface having a fairly uniform light gray appearance.

It will be observed that all of the lead pick-up values in these tests, except that for lead wool at pH 8.9, are in excess of the commonly accepted maximum of 0.1 p.p.m. for drinking water (8, 9). This is due in part to the severity of the tests, for with the extremely intimate contact of the water with the metal surface in the tests with lead wool, more lead is picked up by a given amount of water than would be the case in a service pipe. Likewise, in the tests with the relatively small lead tubing, a unit of water would tend to come in contact with more lead surface than in the usual service line. In the case of the lead pick-up by water stagnant for 24 hr. in the tubing, the value is probably in excess of that which would be encountered in an actual installation, as a result of the high ratio of lead surface to water capacity in this small diameter tubing, and of the absence of any possible dilution of the water which had stood in the tubing as compared to that which would occur in a service line when water was drawn.

Concentrated Metaphosphate Solution

It is readily apparent that with regard to lead, just as with iron and steel, the effect of concentrations of sodium hexametaphosphate on the order of several parts per million differs radically from that of much higher concentrations. The latter exert a definite solvent action upon lead and its compounds, presumably because of the well-known ability of metaphosphate to form soluble complexes with many metals. In fact, the efficacy of these more concentrated metaphosphate solutions, in dissolving, sparingly, soluble lead compounds, has rendered it very effective for the removal of spray residues from fruit (10). Unlike the case of the ferrous metals, simple elevation of the pH to around 8.5 is not sufficient to prevent solution of lead by concentrated metaphosphate solutions. The difference in behavior of concentrated and dilute solutions is by no means peculiar to metaphosphate. It is well known that caustic and lime in moderately high concentrations are very corrosive to lead and that even sodium carbonate has been reported to have such an effect (11).

The exact metaphosphate concentration at which corrosion inhibition ceases and solution of lead commences has not been determined. In parallel lead tubing tests of the type discussed above, however, the following results were observed: after 24-hour treatment with 10 p.p.m. metaphosphate at 500 ml. per min., followed by standing in the pipe for 24 hr., the pick-up of lead was 0.78 p.p.m. and after 48-hour treatment at 500 ml. per min. the pick-up, upon standing for 24 hr., was 0.60 p.p.m. The corresponding pick-ups from parallel tests with untreated water were 1.14 p.p.m. and 0.86 p.p.m., respectively. Thus the inhibiting action upon the lead pick-up appears to extend at least to 10 p.p.m., which figure is probably above the maximum concentration that would be employed in a municipal system.

Conclusion

With lead, as with any of the more common metallic materials of construction, corrosion protection obviously is attained by the formation of a resistant coating or film upon the metal surface. Water treatment for the purpose of corrosion control is but a means to supply ingredients which will form such a coating at the metal surface. When metaphosphate is used for corrosion control, this coating appears to be an adsorbed film of the chemical, or some complex thereof.

The protective film formed upon lead by metaphosphate in concentrations of 10 to 2 p.p.m., and probably even lower, is effective in reducing the pick-up of lead from the metal surface. This inhibitive action appears to be the most marked at about pH 6, the efficacy of the metaphosphate decreasing at values much below this (although at pH 5.2 it still exerts an inhibitive effect), and the protective action being overshadowed by that of the basic carbonate film upon elevation of the pH to 7 or above. The formation of basic carbonate film may be retarded somewhat by the metaphosphate, but it is not prevented.

As in the case of other chemicals widely employed in water treatment, more concentrated solutions of metaphosphate attack lead, in direct contrast to the protective behavior of the recommended very low concentrations in the range below 10 p.p.m.

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Automatic Recording and Control Devices in Tacoma's Water System

By W. A. Kunigk

TO ELIMINATE, wherever possible, the unreliable features in the operation of the water supply and distribution systems of Tacoma, Wash., which are due to the manual operation of certain control units, numerous automatic recording and pressure control devices have been installed during the last few years. The use of these devices has improved pressure conditions over large areas, particularly during times of peak demand, has lessened the demands on operators, and has provided the department with necessary basic information for making additional future improvements.

The principal source of Tacoma's water supply is the Green River, from which water is piped to the city through a gravity system. The intake for this system is located approximately 28 mi. east of the city in the foothills of the Cascade Mountains, the crest of the diversion dam being at an elevation of 908 ft. A single pipe line, 26.6 mi. long and of varying diameter, conveys 52 m.g.d. to McMillin Reservoir, the main storage reservoir on the system.*

Capacity of the two compartments of McMillin Reservoir is 110 mil.gal., and its water level is held at 588 ft. From the reservoir, two large pipe lines, with a combined capacity of 92 m.g.d., supply the water to the distribution system in the city. The older of these lines is 15.3 mi. long and was designed for gravity flow opera-

A paper presented on May 9, 1941, at the Pacific Northwest Section Meeting, Seattle, Wash., by W. A. Kunigk, Superintendent, Water Division, Department of Public Utilities, Tacoma, Wash.

* For a description of this construction and further details concerning various aspects of the Tacoma system see the previous paper by the author (Kunigk, W. A. Tacoma's Water Works Construction Program. Jour. A. W. W. A., **31:** 1575 (1939)). Included in this paper is a map of the Green River watershed and the supply lines to Tacoma.

tion. It still contains about 4 mi. of the original wood stave pipe. The newer one, 13.1 mi. long, has been built of concrete and steel and is operated on static pressure from McMillin Reservoir. Both lines connect with the main control station at the J Street Standpipe in the city, where water level is maintained at 492 ft.—the general pressure level in the high service portion of the distribution system.

The four large standpipes on the high service system receive their supply from the gravity pipe lines or their extensions. The small Northeast Tacoma Standpipe, which is also on the high service system, receives its supply from the low service lines on the tide flats by means of an automatic booster pumping plant.

The North End Reservoir—capacity, 25 mil.gal., spillway crest elevation, 460 ft.—is supplied from the overflow of the North End Standpipe; and the Alaska Street (middle service) Reservoir—capacity, 11 mil.gal. in two compartments, spillway crest, 418 ft.—receives its supply from the overflow of the J Street Standpipe. The overflow from the Alaska Street Reservoir, in turn, furnishes the supply for the Hood Street (low service) Reservoir—capacity, 15 mil. gal., spillway crest, 265 ft.—which supplies the business and industrial area on the Tacoma Tide Flats, practically all of the residential area being supplied from the high service North End and Alaska Street Reservoirs. Combined capacity of all these reservoirs and standpipes is estimated to be 165.75 mil.gal.

A secondary supply of excellent quality is now available from eight deep wells located in the South Tacoma area. The last three of these wells were completed in 1940, making a total supply of 36 m.g.d. Another 2 m.g.d. are available from Mason Gulch Springs and 1 m.g.d. from a single well on the Tacoma Tide Flats.

Capacity of System

Total capacity of the entire system (Fig. 1) is rated at 91 m.g.d. made up as follows:

1. 52 m.g.d. from the Green River gravity system is supplied to the high service system in the city at a water level elevation of 492 ft.

2. 36 m.g.d. may be pumped into the high service system from the South Tacoma Wells by two 20-m.g.d. capacity booster pumping stations, one in South Tacoma and the other at the Hood Street Reservoir. If well water is not required in the high service system, 25 m.g.d. may be supplied to the low service reservoir by gravity.

3. 2 m.g.d. may be supplied to the North End Reservoir from

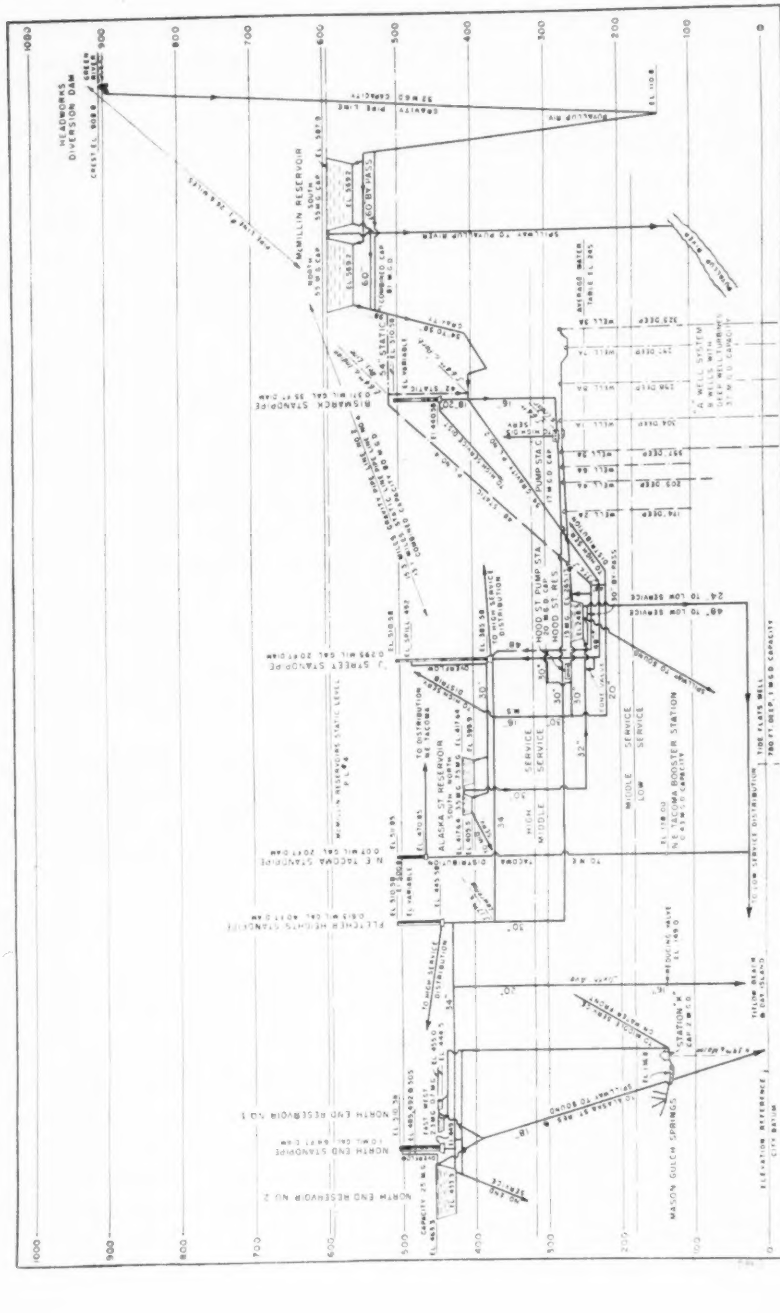


FIG. 1. Schematic Diagram of Tacoma System

Mason Gulch Springs through a manually controlled electric pumping station, and 1 m.g.d. may be pumped into the low service system direct on the tide flats.

The Green River supply line, which operates at a static level of 588 ft. from McMillin Reservoir and extends through the city from the southeast boundary of city limits northwest to the North End

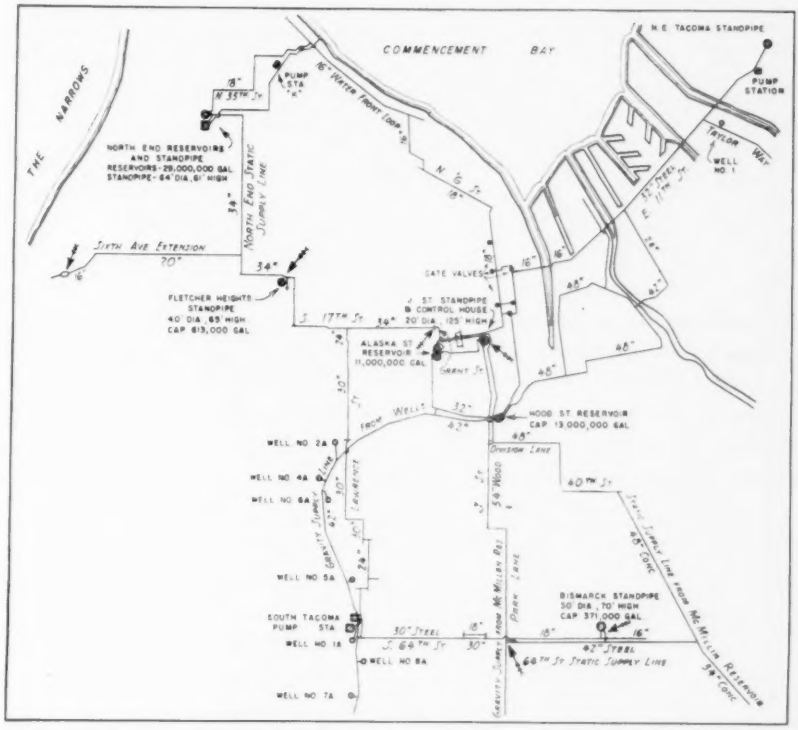


FIG. 2. Main Features of Tacoma Distribution System; arrows show position of reducing valves

Reservoir, constitutes the main artery, or "backbone," of the distribution system. A 42-inch steel pipe on S. 64th St. provides a cross-connection between the gravity supply line on Park Ave. and the static supply line 2 mi. to the east. This line is operated under the same static head as the main supply line from McMillin Reservoir, but with a closed gate at the Park Ave. connection to the gravity supply line.

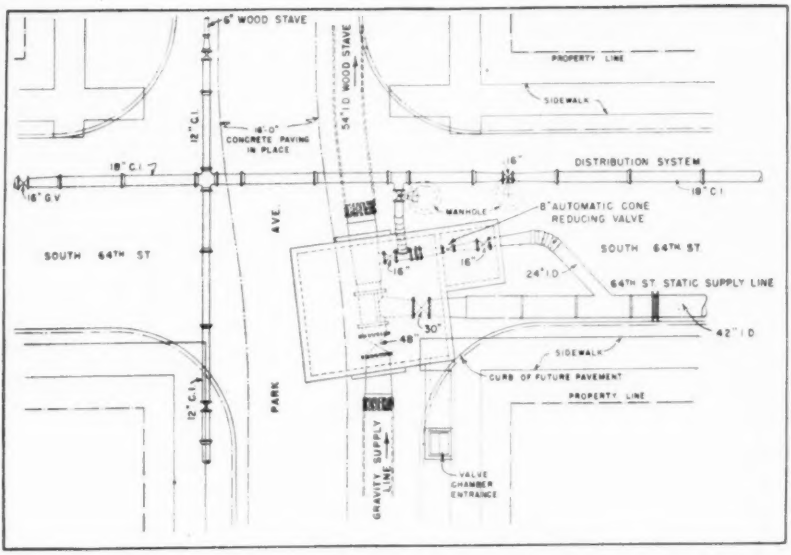


FIG. 3. General Arrangement of Piping at S. 64th St. and Park Ave. Junction of Static and Gravity Supply Lines

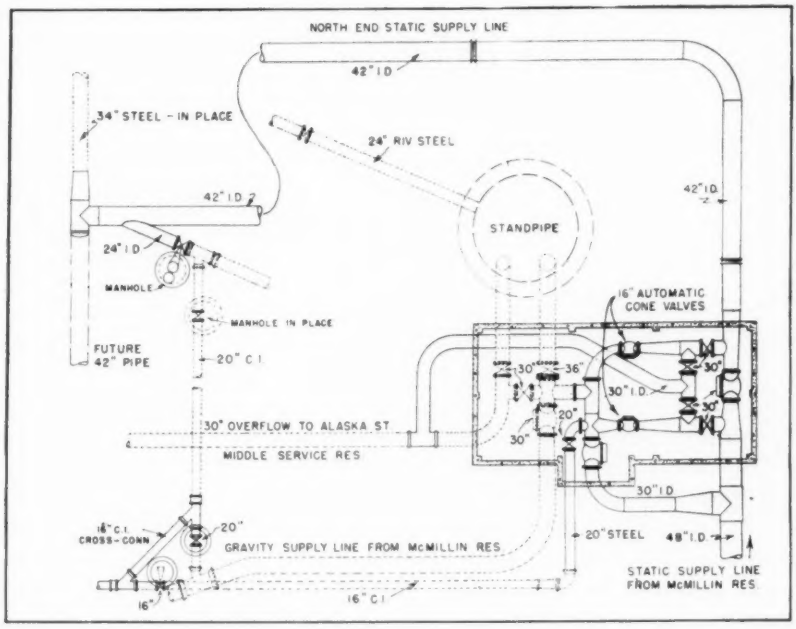


FIG. 4. Piping Layout at J Street Standpipe Control Station

Control Valves

Hydraulically operated automatic pressure reducing valves are maintained at the following locations in the distribution system:

1. At the Bismarck Standpipe, an 8-inch Golden-Anderson cone valve maintains the desired water level in the standpipe. This valve is operated by pressure from the static pipe line in S. 64th St.

2. At the S. 64th St. and Park Ave. intersection an 8-inch Golden-Anderson cone valve supplies deficiencies in the distribution system from the static pipe line in S. 64th St. (Fig. 3)

3. At the Fletcher Heights Standpipe, there is installed a 12-inch Golden-Anderson plunger flow type reducing valve, also operated by pressure from the static line extension to maintain proper water level in the standpipe.

4. At the J Street Standpipe, there are installed two 16-inch Chapman automatic cone valves which can be operated as altitude or relief valves (Fig. 4). These valves use mercury as a balancing medium against standpipe pressures. The elevation of the mercury reservoirs can be adjusted to hold the water levels in the standpipe at any point between elevations of 476 and 492 ft.; they are operated by a "step-by-step" control which will cause either valve to operate from "full open" to "full closed" position, or from "closed" to "full open" position with a change of 2 ft. in the water elevation in the standpipe. With the demand increasing from a 0- to 50-per cent opening of one valve, the water elevation will drop 1 ft. and, by the time the valve is wide open, will drop 2 ft. Because of the long (13.1 mi.) static pipe line in back of these valves, their fastest opening or closing time has had to be limited to 15 min. In the event that the amount of water delivered to the standpipe exceeds the minimum demand at that point in the system, one cone valve may be set to operate as a relief valve, discharging all surplus water to the Alaska Street Reservoir. At the same time, the other valve may be set to operate as an altitude valve on the static line from McMillin Reservoir, supplying any deficiency not furnished by the gravity supply line. Stating this in different words, the gravity line may deliver more water to the standpipe than it demands, with one cone valve spilling the surplus to the lower service and the other cone valve arranged to make up any deficiency in the gravity line supply from the static pipe line.

5. At S. 17th and Grant Sts. a 6-inch Bailey automatic needle valve discharges from the static pipe line extension directly into the high

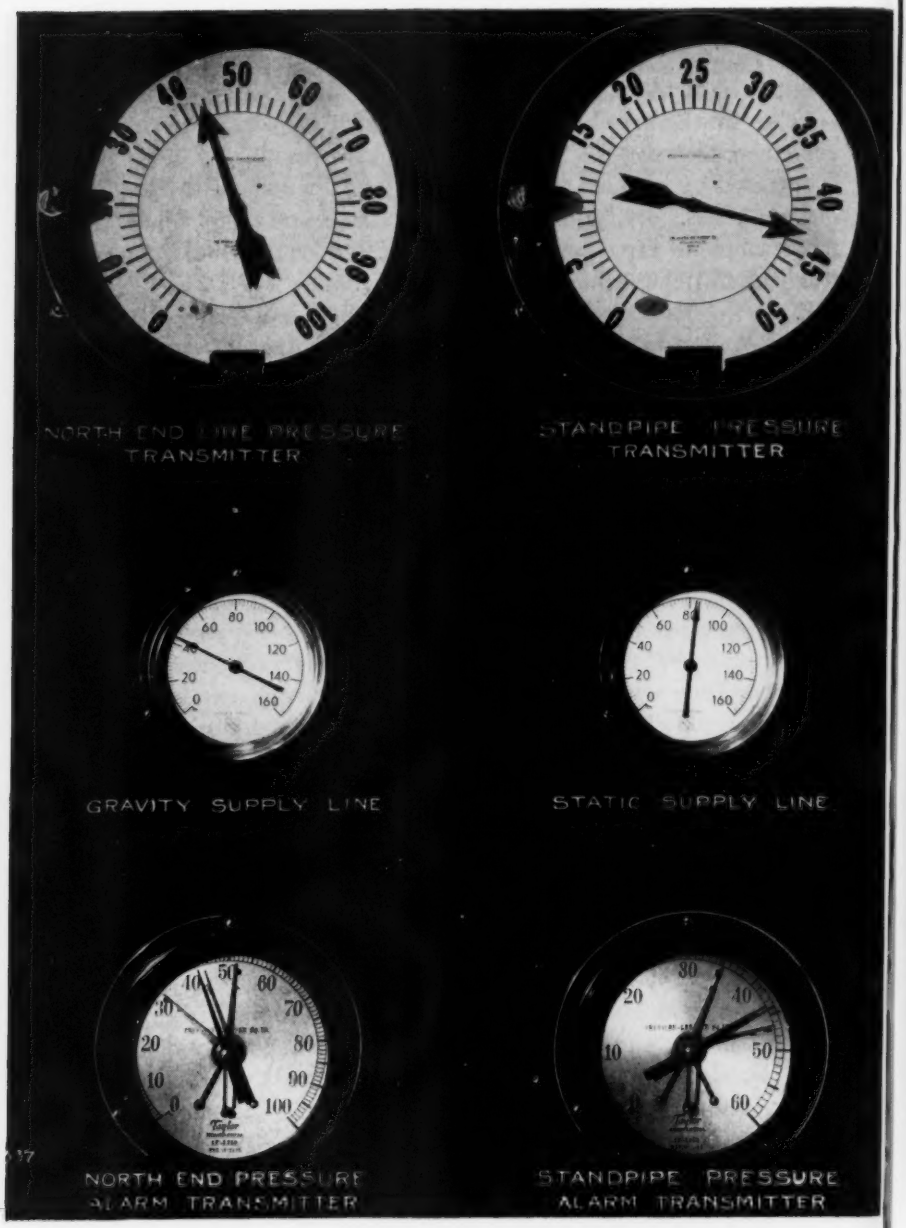


FIG. 5. Gage Board at J Street Standpipe Control Station

service distribution system to maintain pressure during peak demands.

6. At the Sunset Drive crossing of the Sixth Avenue Extension, two pressure reducing valves have been installed in a 16-inch pipe line, reducing the pressure at this point from 130 to 30 lb. to supply the property at much lower levels. A 12-inch Golden-Anderson plunger flow type reducing valve has been installed in parallel with a 4-inch Bailey needle type reducing valve. This combination of a small and large valve on the same line, set at about a 5-pound differential, has proved advantageous, in that the smaller valve takes care of all night flows and the larger one provides for the heavier demand during the day-time hours or during emergencies at night.

Recording Gages

To obtain a dependable and continuous record of conditions in the supply and distribution system, the Water Department maintains a number of gages, recorders, and alarm devices throughout the system. When considering the number of gages that the department has in operation, it must be borne in mind that the City of Tacoma, with a population of only 109,408, covers an area of 46.45 sq.mi. while in the supply system alone there are 61.8 mi. of trunk mains from 36 to 63 in. in diameter, sections of which operate under a head of over 500 ft.

There are in service, in the entire system, 23 pressure recording gages with a range from 0 to 240 lb. per sq.in. Four of these are equipped with one-day clocks and 19 with seven-day clocks. The sizes of the charts used range from 7 to $11\frac{1}{4}$ in. in diameter. Eighteen of these gages are of the Bristol type; three, Brown; and two, American Recorders.

Of the eleven water level recording instruments in service, four are Stevens; one, Gurley; two, Leeds and Northrup; and four, Foxboro. Five flow recorders, of which four are of the Simplex Venturi type and one, a Sparling, are in use.

At the J Street Standpipe control building are located two high and low pressure Taylor alarm gages (Fig. 5) which transmit the alarm over a mile to the Hood Street Pumping Station where there is always a man on duty. One of these gages is connected to the J Street Standpipe and the other to the static transmission line north of the standpipe.

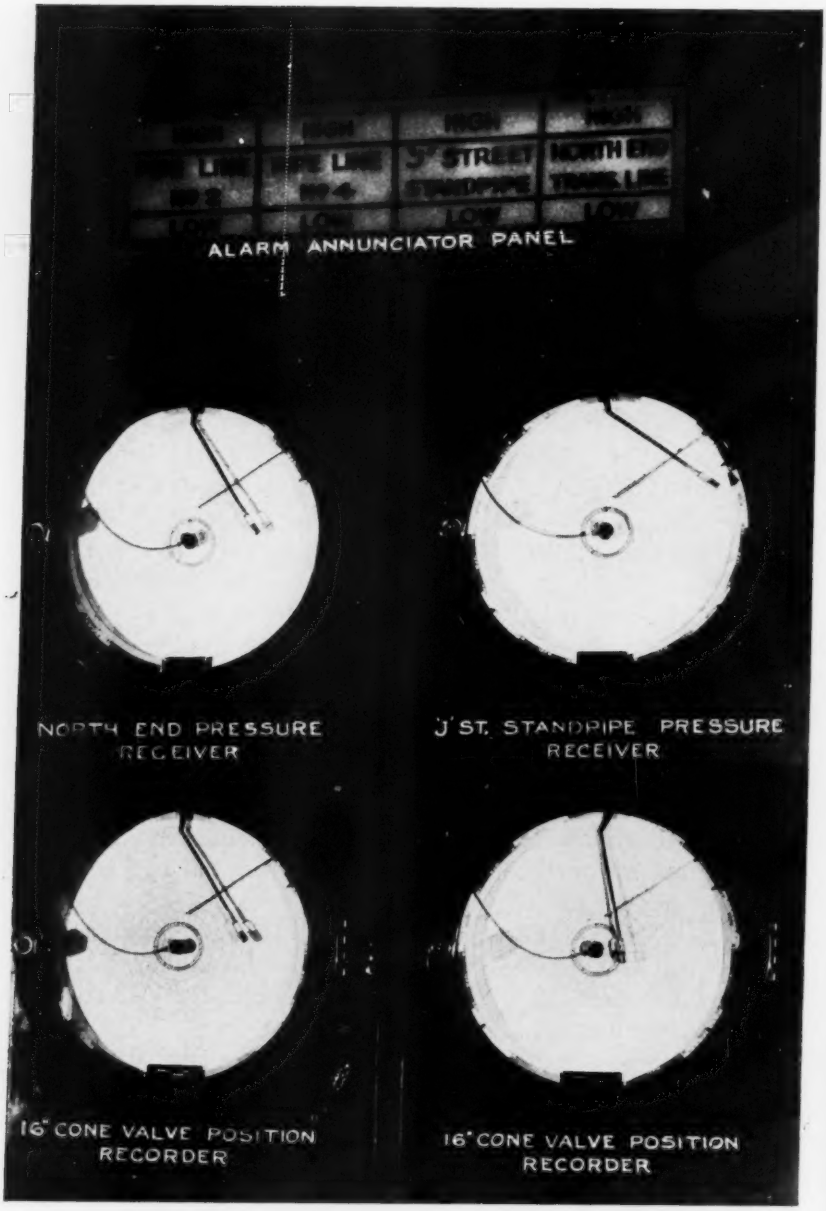
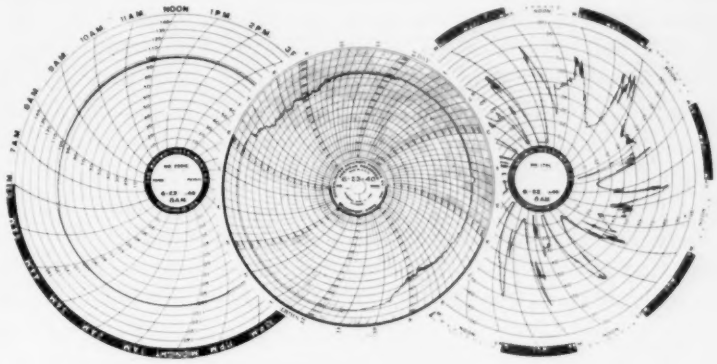
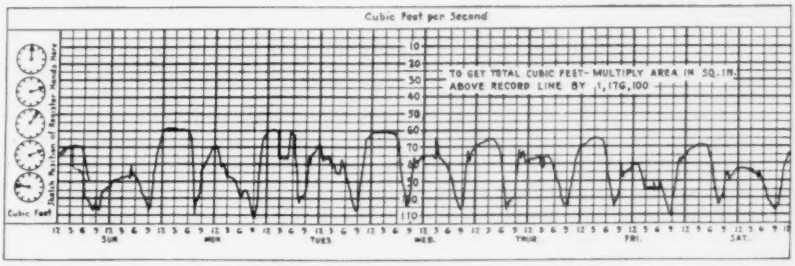


FIG. 6. Long Distance Receiver Board at Hood Street Pumping Station

Two Brown indicating transmitters relay the standpipe and North End transmission line pressures to seven-day recording chart receivers (Fig. 6) at the Hood Street Pumping Station.

At the J Street Standpipe, are also located two Brown gate position transmitters, the indications of which are transmitted to, and re-





GREEN RIVER GRAVITY PIPE LINE FLOW RECORD
INDICATED BY 58"x 29" VENTURI METER

FIG. 7. Pressure and Demand Charts on Supply Lines From McMillin Reservoir to Tacoma

corded at, the Hood Street Pumping Station. These recorders indicate graphically on seven-day charts the percentage opening of the two automatic cone valves.

At the Hood Street Pumping Station there are in service two high and low pressure Taylor alarm gages which bring to the attention of

the operator any abnormal pressure fluctuations in the gravity and static supply lines.

On the gravity pipe system there are three alarm gages in service which set off alarms at the headworks, McMillin Reservoir, and at the patrolman's house in case of sudden water level or pressure drops.

An interesting gate position recorder is also located at the South Tacoma Pumping Station where the percentage opening of four 12-inch cone valves is recorded on a single-strip Leeds and Northrup instrument. This record is important as it gives to the station operator information regarding the four cone valve positions during operation. In this case the cone valves act as combination check and throttling valves for four 3,500-g.p.m. pumping units.

The record obtained from these various instruments (Fig. 7) is invaluable in working out analyses for correction of deficiencies in the system and also for the purpose of establishing facts in damage suits against the Water Department. No evidence speaks louder for itself than facts recorded at the time of any accident or change of conditions. The record of an earthquake as obtained from some of the pressure recording instruments, for instance, is a good illustration in point. The matter of the additional safety as provided by automatically controlled operation in a system does not need to be emphasized in these times of unrest and possible trouble.

Water Supply at Cincinnati

By the Cincinnati Staff

ON THE following pages is presented a panoramic description of the Cincinnati water supply. Each of the phases of its work has been reported by the member of the organization directly responsible. Organization of personnel is as shown in Fig. 1.

Following is an outline of the various sections and a list of the authors of the paper:

Part 1. Introduction—CARL A. EBERLING, Superintendent.
Part 2. Pumping Plants—RALPH E. DUHME, Assistant Superintendent—Supply and Purification.
Part 3. New Filtration Plant—CLARENCE BAHLMAN, Water Purification Supervisor.
Part 4. Distribution System—WILLIAM SAHND, Water Works Supervisor.
Part 5. Distribution System Maintenance—JAMES H. RIMMER, Assistant Water Works Supervisor.
Part 6. Commercial Division—M. F. HOFFMAN, Assistant Superintendent—Commercial Division.
Part 7. Legal Phases—ED F. ALEXANDER, Assistant City Solicitor.

EDITOR'S NOTE: The method of presentation employed in this description of the Cincinnati water supply is particularly desirable, both from the fact that each phase of the system is presented from the point of view of the person best qualified to speak on that subject and because it represents a visualization of the "team work" necessary to the smooth operation of a large water works. The proper combination of these subdivisions into an integrated unit of organization is, of course, the mark of a good superintendent.

A series of papers presented on May 15, 1941, at the Ohio Section Meeting, Cincinnati, Ohio, by the staff of the Cincinnati Water Works, under the direction of Carl A. Eberling, Superintendent.

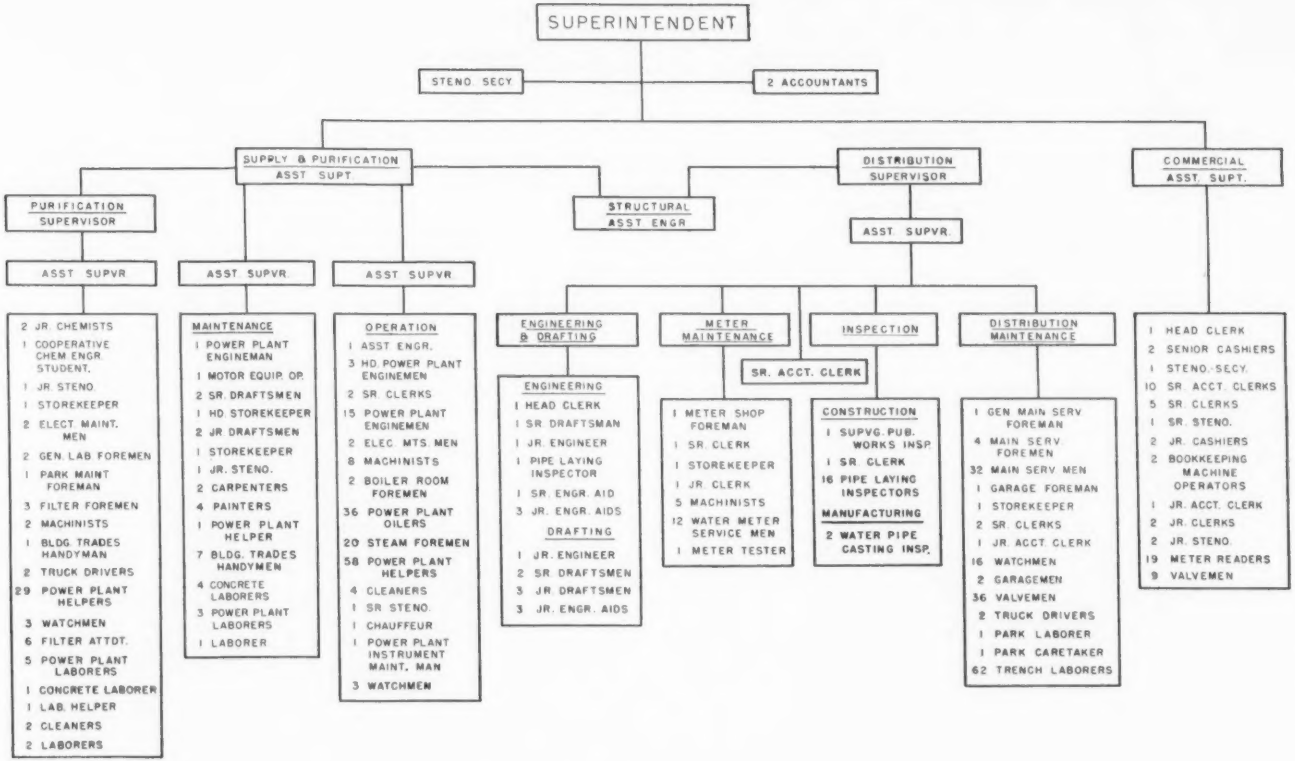


FIG. 1. Organization of Personnel

Introduction

When the City of Cincinnati was founded in 1788, its abundance of springs provided a ready water supply that was adequate for all city needs until 1799. At that time, private wells were drilled and a charge of 25 cents per week per family was made for their use. Then, in 1821, the first water for public supply was pumped from the Ohio River, the supply being distributed through a system consisting of 10-inch oak logs, 12 ft. long, in which holes $2\frac{1}{2}$ in. in diameter had been bored. The pump was of the treadmill type powered by horses or oxen. Finally, in 1824, the first steam pumps were installed, and this was the last improvement to the system under private ownership, for on June 25, 1839, the city purchased the water works at a price of $300,000. Since that time additions have been made from time to time as demands have increased and as the general recognition of the dissemination of disease through water supply has progressed.

It was in 1896 that the Ohio General Assembly passed the Water Works Act under which the Governor appointed a board of trustees, called the "Commissioners of Water Works," to undertake the administration of the water works system. Under this board, the "New Water Works" was designed, and constructed (completed in 1907); and this new plant is the one which, with certain additions to take care of increased demands, is operating in Cincinnati today. Consumers now approximate 106,000, using an average of 63 m.g.d. through 1,376 miles of mains and contributing a gross revenue of approximately $2,500,000 per annum.

Pumping Plants

Pumping facilities of the Cincinnati Water Department comprise a low lift station and intake works for delivering the raw Ohio River water into the settling reservoirs, a combined high and low pressure station for delivery of the treated water to the consumers, and a booster pumping station for the supply of the Western Hills area.

The intake pier is a masonry structure located in the deepest pool of the river near the Kentucky shore and reached from that point by a truss span bridge. The pier is constructed to form two wells, one an inlet well provided with four openings two high and two low, all controlled by sluice valves. A division wall, also provided with a valved opening, connects the inlet well to what is termed the shaft well, the latter being a continuation of a vertical shaft which ter-

minates one end of the supply tunnel. This well is provided with two valved openings into the river and these permit bypassing of the inlet well.

Within the inlet well is located a traveling water screen of extra large size (10 ft. wide and 95 ft. between the upper and lower

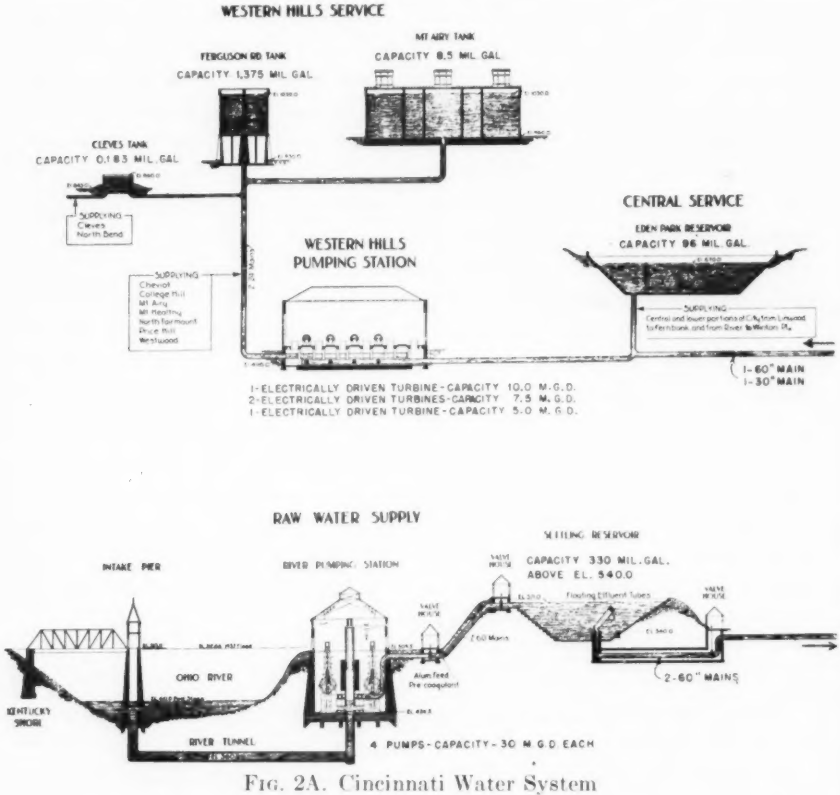


FIG. 2A. Cincinnati Water System

sprockets), designed to screen the river water at 150 m.g.d. This screen is in the form of a continuous belt constructed of 112 wire screen panels connected by the sprocket chains. Features of the water screen equipment are its provision for directing the flow of water in the event of a power outage and for automatic starting of the screens in the event that the water in the wells should be lowered due to the clogging of the screens with debris. Flushing water for cleaning the screens is furnished by a deep well pump located within the inlet well.

Located within the bedrock beneath the river and connecting the intake shaft is a masonry tunnel, 7 ft. in diameter, which terminates in a typical vertical shaft at the raw water pumping station.

River Pumping Station

The pumping equipment at the raw water pumping station comprises four vertical type triple-expansion pumps, the displacement

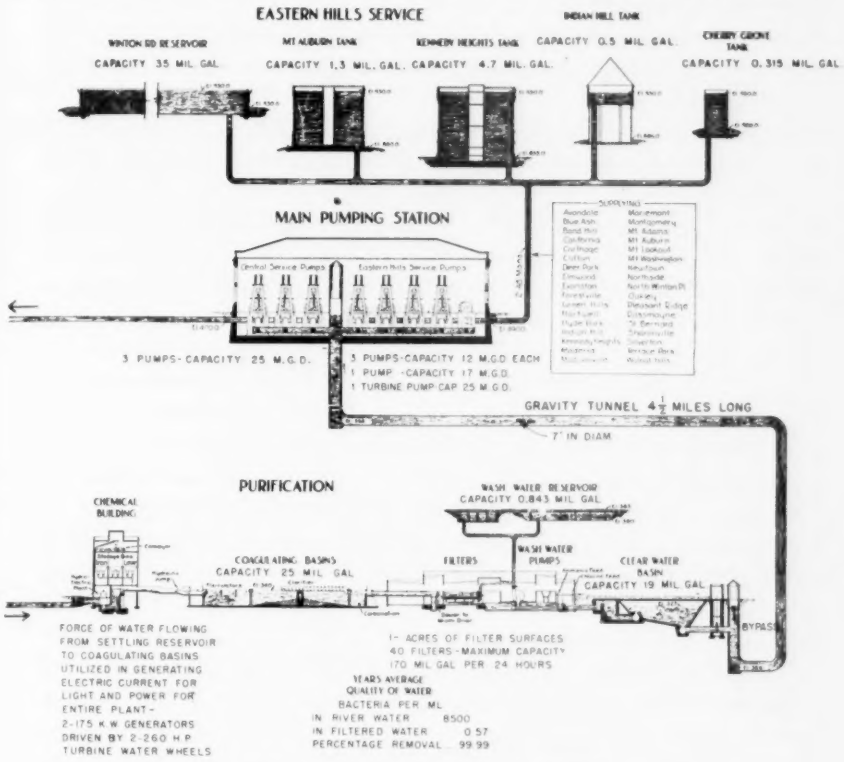


FIG. 2B. Cincinnati Water System

plungers of which have an 8-foot stroke and deliver 1,361.7 gal. of water per revolution. The rated capacity of each of these engines is 30 m.g.d., making a total plant capacity of 120 m.g.d.

This equipment is located within a circular dry pit constructed on a timber caisson, the top elevation of which forms the floor of the pump pit and is 6 ft. below the zero elevation of the Ohio River, or a total depth of 85 ft. from the operating floor. The pit measures 98

ft. in diameter and the entire structure is held in a static position by the combined weight of the masonry walls, the four engines which total 5,400 tons and a center counter-weight which adds an additional 4,500 tons. During periods of extreme high river stages, water is placed in the pit to an elevation of approximately 12 ft. as a safeguard against possible flotation or shifting of the caisson.

The steam power for operating the pumps is generated by five Sterling type boilers totaling 2,100 h.p. Fuel is procured by barge delivery to the plant where it is elevated and stored by mechanical methods, the storage amounting to 8,000 tons, or approximately ten months' supply.

At present four vertical type centrifugal pumps, each rated at 15 m.g.d., are being installed to provide a reserve in the event of an enforced shutdown of the steam units during periods of peak demand, which, at times, exceeds the 90 m.g.d. firm capacity of the station. These pumps are rather novel in that they will take suction water in conjunction with the steam units and will discharge into the same headers. The method of installation allows them to be driven through an extended vertical driveshaft enclosed and supported by a continuous cantilever type steel frame with the motors located on the ground or operating floor. In conjunction with this new addition, the discharge lines from the steam driven pumps have been provided with inclined swing type check valves. The four 48-inch discharge lines converge into two 60-inch force mains which lead to the settling reservoirs located on the higher ground opposite the filtration plant and a portion of the energy expended in elevating the water to these reservoirs is retrieved by water wheel generators located on the outlet lines from the reservoirs.

The electrical system at the combined filtration plant and river pumping station consists of the automatically operated water wheel generators which normally produce current in excess of the plant requirements. These units furnish alternating current of 4,150 volts and, through motor generator sets located in the River Pumping Station, furnish that plant with 220-volt direct current. The new electric-driven pumps at the station operate at 4,150 volts and, together with the water wheel generators, are tied into a private substation of the local power company located at the filtration plant to form both a reserve for plant use in general and for furnishing the power for the new pumping equipment which, of course, is much in excess of that generated by the water wheels.

Main Pumping Station

From the filtered water reservoir at California, Ohio, the water is conveyed by means of a masonry tunnel located in bedrock, approximately 4½ mi. long, to the Main Pumping Station which is located on the Ohio River at its northernmost point in the vicinity of Cincinnati. At this station the water is taken from the vertical tunnel shafts through a suction header connected to two groups of pumping equipment. The topography of the city is such that three services at different pressures were required to distribute the water properly, these being the low, or Central, service supplying the city proper, the Mill Creek Valley, which divides the hills to the east and west, and the low areas adjacent to the Ohio River.

At the Main Pumping Station three vertical type triple-expansion displacement pumps, each rated at 25 m.g.d., provide the water supply to the Central Service. The higher grounds east and north of the city proper are supplied by the Eastern Hills Service pumping units which consist of three 12-m.g.d. and one 17-m.g.d. vertical triple-expansion pumps and one 25 m.g.d. steam-turbine-driven centrifugal pump. This gives a total pumping capacity of 75 m.g.d. for the Central Service and 78 m.g.d. for the Eastern Hills Service, the average being 35 and 30 m.g.d. respectively, with maximum days of 58 and 48 m.g.d.

The steam plant at the Main Pumping Station is more or less like that at the River Pumping Station except that its load factor is about two and one-half times as great, due to the higher heads to be pumped against.

Western Hills Pumping Station

The Western Hills Pumping Station situated northwest of the city is essentially a repump or booster plant in which the suction water is taken from the Central Service supply and distributed to the high ground or hills west and north of the city proper. A new electrically-operated station has been completed and is now in its third year of service. The equipment comprises one 10-m.g.d., two 7½-m.g.d. and one 5-m.g.d. pumps, all of the horizontal two-stage centrifugal volute type, powered by 2,300-volt synchronous motors. These pumps are provided with automatic plug type check valves and with suction and discharge valves of the same type, but hydraulically operated through manual control. The station is modernized to the extent that all

functions are controlled from an operating panel with telemetering of the respective tank elevations.

Operation

Operation of the division is carried on by a personnel of 260, representing a highly diversified group of trades and professions. Recently a straight 8-hour shift, in place of 8- and 16-hour alternating shifts, was inaugurated at the California Plant, the old system having been in use since the opening of the works in 1906 because of transportation difficulties at night. This change permitted better arrangements for the relief watches, which at best present many problems arising from off days, vacations and sickness.

All engineering, both for maintenance and improvement, is performed by the division's own staff, which includes a mechanical, an electrical and a structural engineer, as well as draftsmen and assistants. This group designed and constructed about thirty contracts aggregating almost a million dollars within the past two years, a very noteworthy accomplishment considering the expediency with which the funds provided had to be used.

New Filtration Plant

Purification of the city's water supply was started late in 1907, when the "New Water Works" was placed in service. The first step in the purification takes place in two primary settling reservoirs, each of about 200 mil.gal. capacity. These are operated in parallel, the theoretical retention period being reduced to about 36 hr. because of short circuiting. Since 1927, the occasional use of alum in these basins, as a primary coagulant, has been practiced at times of unusually turbid raw water.

After primary sedimentation, iron sulfate and lime have been the only coagulants used in the secondary basins. Following this treatment, the water passes through rapid sand filters and then is disinfected by ammonia-chlorine treatment.

The original filtration plant, of 112 m.g.d. rated capacity, was one of the pioneer rapid sand plants of America, and was eminently successful in its prime. As early as 1930, however, serious problems arose, as the result of the high peak demands of summer, the increasing pollution of the river, inability to feed sufficient water to the filters without bypassing the basins, failure of much of the original equipment, and the mechanical impossibility of efficiently installing

modern devices and procedures in the existing set-up. The rehabilitation of the filtration plant (Fig. 3) was initiated in 1936 and completed during the summer of 1938. The project cost $3\frac{1}{4}$ million dollars, of which part was contributed by the Public Works Administration.

A new chemical house was constructed, with two parallel-operated settling basins located between it and the filtration plant proper. In the plant itself, new pipe and filter galleries were constructed, 14 new filters built, and 26 old filters completely modernized, with space

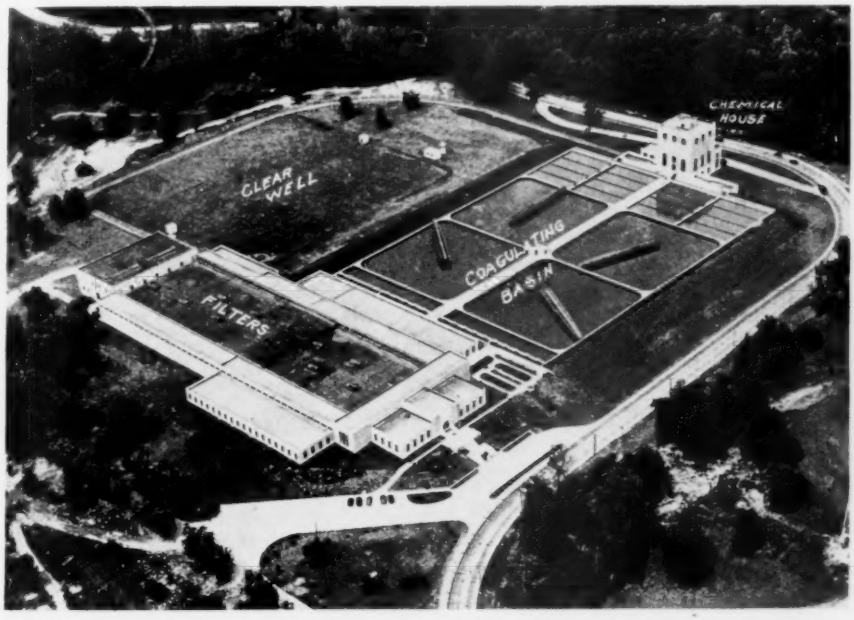


FIG. 3. New Filtration Plant at Cincinnati

remaining for seven future units. Beautification was not ignored; fish pools, a lily pond and the conventional garden, ornamental tile walls and floors and landscaping have attracted favorable comment. The offices, lecture room and five-room laboratory suite are air-conditioned. Covering of the clear water reservoir was included in the project. Later, the Department remodeled the old chemical house and converted it into a modern and completely equipped storeroom, machine shop, electrical repair shop, paint shop, forge and welding shop, lunch room and lavatory.

Chemical House

In the chemical house the water passes through one, or two, 260-h.p. Leffel Turbine water wheels with direct connection to vertical Westinghouse generators (3 phase, 60 cycle, 4,150 volts, 175 kw.) cross-connected with the public utility system. All valves in the entire plant are electrically operated. The chemicals, with the exception of activated carbon, are unloaded by Brady pneumatic equipment and stored in steel bins, each holding from 180 to 240 tons of the various chemicals. The chemicals are then fed through gravimetric Omega dry feeders. The carbon feeders are in a separate room, designed for dustless feeding. The chemicals are added at the head of the two hydraulic jumps which deliver into the two settling basins.

Settling Basins

Each of the settling basins, operated in parallel, measures 500 ft. by 175 ft. by 20 ft. deep. Four rows of Dorr flocculators occupy the first 120 ft. of each basin, the remainder being utilized for sedimentation, and equipped with two Dorr clarifiers with provision for continuous sludge removal. At the outlet end, transite pipe for recarbonation is provided, but a recarbonation plant was not included in the rehabilitation program. At 160 m.g.d. rated capacity, the retention periods are 1 hr. for flocculation, 2.75 hr. for sedimentation and $\frac{1}{4}$ hr. for recarbonation.

Filtration Plant

There are 40 filters, each of 1,400 sq.ft. sand area and filled with 21 in. of graded gravel and 27 in. of filter sand of 0.42 to 0.44 mm. effective size. Filters are washed at about 23 to 25 in. per min. rise, reducing to about 20–22 in. rise in mid-winter. Builders Iron Foundry Venturi-type controllers and Cochrane electric filter control panels are provided. Up to the present year the filters were operated as 5-m.g.d. units (156 mil.gal. per acre-day) but the rate has since been reduced to 4 m.g.d. per unit (125 mil.gal. per acre-day). There are ample filters for this lower rate, which possibly may yield still better bacterial efficiencies.

The chlorine and ammonia treatment rooms are provided with ventilating fans capable of two air evacuations per minute. The wash water reservoir has a capacity of 843,000 gal., with wash water pumping capacity of 13,000 g.p.m.

The covered clear water reservoir holds 20 mil.gal., and delivers into the gravity tunnel, which is 7 ft. in diameter, $4\frac{1}{4}$ mi. long, and terminates at the Main Pumping Station.

Principal Purification Problems

Difficulties with poor coagulation and smoky effluent, so frequently encountered in the old plant during the winters, have been eliminated completely by the new mixing and flocculating procedure. With the assistance of primary alum coagulation, it now is possible to maintain practically constant clarity in the filter influent, regardless of heavy runoff in the river.

Although plant scale comparisons in the two parallel basins have demonstrated the superiority of ferrous sulfate over alum as a coagulant for the Ohio River water, its storage and uniform feeding have presented most aggravating problems because of its tendency to harden in storage. Recent studies have shown that ferric sulfate gives better coagulation at lower cost than ferrous sulfate, and that the former presents no difficulties in storing and feeding.

Short filter runs, due to algae in the river, have at times interfered considerably with operating routine. During the first summer after the new sand was in use, as much as 8.9 per cent of the wash water was used during one week. Thus, the provision for ample wash water pumping capacity was necessary.

High pH is necessary with ferrous sulfate coagulation. An average pH of 8.8 in the filter influent causes enlargement of the sand grains due to lime incrustation, calling for renewal of sand in about 10 to 15 years. On the other hand, such deposition has a stabilizing effect. Filtered water has an average pH of 8.4, and complaints of corrosion, red water or incrustation of hot water heaters are practically never encountered.

Tastes and odors have at times been very severe, but probably are less troublesome than at many other plants, so activated carbon is rarely used for more than about six weeks per year. Fully 80 per cent of the taste occurrences due to river conditions may be classed as stagnant, algal tastes, or as ill-defined "melted ice" or "river" tastes in winter; and, in general, less than 20 per cent of the trouble is of the phenolic origin which is so difficult to combat. Chlorinous tastes and odors are sometimes encountered in winter and the ammoniation process is not always successful in reducing these tastes.

Bacterial records show that pollution in the Ohio River has in-

creased materially during the last six years, reaching a maximum monthly and annual coliform index of 28,800 and 10,600 per 100 ml., respectively. The final chlorinated water averages about 1.8 presumptive and 0.20 coliform index per 100 ml. Routine samples from the distribution system, tested by the City Health Department, show an even lower index, suggesting that the disinfecting action is continued after the water leaves the plant. Non-confirming presumptive positives frequently appear explosively, seemingly uncorrelated with climatic or river conditions. Probably, these can be eliminated only by break-point chlorination.

Distribution System

The topography of Cincinnati and of Hamilton County is such that it is necessary to divide the city and county into different districts to insure the proper distribution of its water supply. These districts are the Central, Eastern Hills and Western Hills Services with two intermediates, the California and the Cleves Services (Fig. 2).

This system is supplied through 1,375.66 mi. of mains, 4 in. to 60 in. in size, of which 971.79 mi. are in the city and 403.87 mi. in the county. Each of these services has either a reservoir or tanks, or both, which serve for the storage of water as well as equalizing the work of the pumps at the pumping station.

The Central Service comprises the lower level of the city bordering on the Ohio River, with a total frontage of 20 mi., and the major portion of the Mill Creek Valley. The Central Service is served by the Eden Park Reservoir, which consists of two adjacent basins functioning in unison or separately as desired, and having a total capacity of nearly 100 mil.gal. This service likewise supplies the water for the Western Hills Pumping Station.

The Eastern Hills Service comprises all the territory north of Columbia Parkway and east of the old Miami and Erie Canal. It is served by:

1. Kennedy Heights Tanks, consisting of five tanks, 40 ft. in diameter and 100 ft. high, with a total capacity of 4.7 mil.gal.

2. Mt. Auburn Tanks, consisting of two tanks, 40 ft. in diameter and 70 ft. high, with a total capacity of 1.3 mil.gal.

3. Winton Road Reservoir, constructed of reinforced concrete, 400 ft. square and 30 ft. deep, with a total capacity of 35.0 mil.gal.

4. Mt. Washington Reservoir, constructed of reinforced concrete,

60 ft. in diameter and 141.5 ft. high, with a total capacity of 3.0 mil.gal.

5. Indian Hill Tank, constructed of reinforced concrete, 60 ft. in diameter and 25 ft. high, with a total capacity of 0.5 mil.gal.

6. Cherry Grove Tank, constructed of steel, 40 ft. in diameter and 70 ft. high, with a total capacity of 0.315 mil.gal.

California Service comprises the eastern section of the city and county and is served by the Three Mile Control Reservoir, constructed of reinforced concrete, 90 ft. in diameter and 23 ft. high, with a total capacity of 1.0 mil.gal. This service is to be served through drought periods by a pumping station located at the filter plant and in normal times from the Eastern Hills Service.

Western Hills Service comprises all the territory north of Riverside Drive and west above the Mill Creek Valley Plain. It is served by the Mt. Airy Tanks, consisting of fourteen steel tanks, five of which are 22.5 ft. in diameter; two of which are 25 ft. in diameter, and seven of which are 50 ft. in diameter and 70 ft. high, with a total capacity of 8.5 mil.gal.; and the Western Hills Tanks, consisting of four steel tanks 30 ft. in diameter and 65 ft. high, set on a concrete base 35 ft. above the ground grade, with a capacity of 1.375 mil.gal.

The Cleves Service comprises the Village of Cleves and North Bend and is supplied by a reinforced concrete tank 40 ft. in diameter and 22 ft. high, with a capacity of 0.183 mil.gal. The supply of this tank is through the Western Hills Service.

The active meters in service are 106,038, of which number 84,556 are in the city and 21,482 are in the county. The personnel of the Distribution Division is as shown in Fig. 1.

Distribution System Maintenance

Rigid inspection of the manufacture of main and branch materials, and of their installation up to and including the consumer's meter, has insured as high a grade of materials and workmanship as possible in the Cincinnati system. The Inspection Department inspects the manufacture of all cast-iron pipe, specials, valves and miscellaneous castings, all steel pipe and specials, and all copper tubing and brass fittings to be installed in the distribution system. It also inspects the installation of all mains and service branches up to and including the meters.

During the past year the Inspection Department also supervised, furnished the necessary engineering for, and inspected the construc-

tion of two reinforced concrete reservoirs, one of $1\frac{1}{8}$-mil.gal. and the other of approximately 3-mil.gal. capacity. During that time, too, the Meter Department inspected 2,926 new meters before installation and repaired and inspected 13,774 used meters. In following a policy of replacing meters free of charge, unless damaged by hot water, freezing, or malicious destruction, the Meter Department removed 8,278 defective meters and replaced them with new or reconditioned ones.

Leak Detection

Whenever water shows up on the surface of the ground, through cellar walls, or in similar places, a water works valve crew is dispatched to the scene to attempt to locate the leak by listening in on all appurtenances with "Sonoscopes." When the leak cannot be located in this manner, a sample of the water is sent to the water works chemist for analysis. If the sample proves to be filtered water, the engineer in charge of leak detection is sent out to locate the leak with his more sensitive detector apparatus.

The Valve Department, which gives 24-hour service, is made up of nineteen 2-man crews and four 4-man crews on the day shift; four 2-man crews on the afternoon shift; three 2-man crews on the night shift; and two 2-man crews acting as relief. This department receives and investigates all complaints of leaks, lack of pressure, and other similar difficulties, and notifies of and makes all shut-downs in the distribution system, no one else being permitted to shut down valves.

The original valve crew truck has recently been replaced by two new trucks which are equipped with 6-man cabs, air compressors, air-turning machines for valve operations, and every conceivable key and tool developed for that type of work. Each truck is used to make regular examinations of the valves in one-half of the city- and county-system, and thereby make possible a frequent check on the condition of all the various valve equipment. The trucks are also used in the shutting down of large trunk mains and are equipped with demolition tools and pneumatic pumps to aid in making repairs.

Since at least 90 per cent of all leaks have been found on service branches, the water department has, for nine years, maintained all such branches up to the curb cock. If leaks are found behind the curb cock, the owner of the property is notified of the leak and required to have it repaired within three days. When these branches

fail, they are replaced by, and with, materials inspected by the department itself. This procedure has eliminated much of the leakage and has made it possible to extend the distribution system into much of the surrounding county without a proportionate increase in maintenance forces.

During 1940, the Maintenance Department repaired 1,226 and renewed 990 defective service branches. In its reports, no distinction is made between main line leaks and breaks as a main leak is considered a potential main break; so the data indicate that, during 1940, 392 main leaks were repaired.

In the construction of 16-inch and larger mains, specifications call for a pea gravel backfill up to the spring line of the pipe. It is felt that this practice eliminates the settling of the mains and so reduces the possibility of future leaks or breaks.

Other Duties

The Maintenance Department installs all main extensions 12 in. or less in diameter, except in street improvement projects or private sub-divisions; furnishes valve crew and automotive equipment for pitometer engineers; and prepared holes for pipe cleaning.

During 1941, the department actually cleaned 1,000 ft. of 48-inch main by hand when a permit to open the paving on one of the main roads was not granted. In this case, the main, which was 33 years old, was found to be oversize. Although standard 48-inch pipe could have been installed, such a procedure would have resulted in a smaller inside diameter at the two holes for the pipe cleaner and the additional four holes for the cement lining work. With the locally developed pneumatic diamond points and gouges, two 7-foot and four 4-foot sections of the pipe were removed, the work in the main completed, and the same pieces reinstalled in the main with mechanical couplings, the tools having cut a $\frac{1}{2}$-inch groove through the 2-inch thick metal all around the main.

The maintenance of the grounds and all minor repairs to the tanks are also taken care of by the Maintenance Department; and all major repairs are made by contract.

Equipment

The equipment of the Maintenance Department has over the past few years undergone a great improvement. Air compressors and

their demolition tools have replaced bull points and sledges; and pneumatic hammers with cutting tools of the department's own design have supplanted the old-fashioned diamond points for cutting cast-iron pipe. The calking of the larger lead joints with pneumatic tools and the use of harder lead have both proved beneficial in speeding up repairs and in economizing man power.

The engineering and drafting personnel, besides making all construction drawings and platting all structures in their proper books, also designed the "Cincinnati Standard Valve and Water Works Connection" sleeves and valve.

Commercial Division

All on and off orders and special inspections are completed by eight turnkey-collectors who also collect delinquent bills. Each turnkey-collector covers a prescribed area. Applications for service (on and off), changes of name, and billing corrections, complaints and service investigations (including "stuck" meters), checking and extending of meter readings, billing of consumers' charges, auditing of bills, collections, and distribution and balancing of revenues are all taken care of by 31 employees. Meter readings and re-reads are handled by 20 meter readers. In other words, a total of 59 people handle all clerical and accounting work incidental to 106,000 accounts.

Meters are read quarterly and bills are mailed quarterly, except on 2,000 accounts which are read and billed monthly. These latter are called "commercial" accounts, and produce 50 per cent of the revenue. Approximately 20 per cent of all meters are read monthly, but the accounts are billed quarterly. These meters are located in the oldest part of the city in the area where the most leaks occur. For purposes of the Commercial Division, the area served by the Cincinnati Water Works is divided into nine districts, each billed at ten-day intervals over a period of three months.

As meters are read, exceptions are noted on the meter reading sheets. The meter shop is notified of defective meters; consumers are advised of excess consumption. Extraordinary increases in the registration of water are followed up by special inspections to ascertain causes and to see that these are remedied.

Charges are extended and posted, by means of billing machines carrying control sheets, to three-part post-card bills. The bills consist of bill, with cashier's stub (mailed under one-cent metered postage), office (ledger record) card and delinquent notice. When

district billing has been completed, bills are audited and charges given to the general bookkeeper for control purposes. Bills are mailed and office records passed to the unit clerk.

Payments represented by cashiers' stubs, after having been balanced by the cashiers, are passed to the unit accounting clerk who removes the corresponding office record and then balances these with the total for that unit. This is a verification of the day's posting and provides a daily balancing of all accounts.

Approximately 80 per cent of all bills are paid within the ten-day period allowed. Delinquent notices, a by-product of the addressographed bill, are mailed on the unpaid accounts, giving ten days of grace. At the end of twenty days shut-off bills are prepared on the remaining $2\frac{1}{2}$ per cent unpaid accounts (including $1.00 for city and $1.50 for county collection charges), and given to turnkey-collectors. All are usually collected. Very rarely is water shut off for non-payment as arrangements can be made for partial payments where necessary. Then all cash receipts are deposited with the City Treasurer for the Water Works Fund.

The Commercial Office is the chief public contact unit of the department. All new service branch and meter applications, service investigation and similar inquiries are cared for promptly. With meter readers and turnkey-collectors instructed always to be courteous and conscientious and with all correspondence handled with dispatch and efficiency, consumer relations are splendid. The use of mechanical office equipment expedites all work with accuracy and neatness and the cycle system of reading and billing and collecting averts peak loads and promotes a uniform flow of the work.

Legal Phases

The chief legal problem affecting city water works systems, day in and day out, is that of establishing a sound method of collecting tens of thousands of individual bills, mostly small in amount. From the very necessities of the case, the city conducts a large credit business. It cannot collect cash for its water. It furnishes the water and after it has been furnished, it seeks to collect payment.

Its credit business is not like that of the installment house business, where the seller may take back the property if the payments are not made. It is not even quite like the business conducted by the neighborhood grocer, who can pick his customers and handle personally those who do not pay their bills.

The city is impersonal. It does not know its customers. It provides them with water and expects them to pay for the water furnished. If they do not pay, it can turn off the water, but if they move away without paying their bills, the city is ordinarily without recourse.

The delinquents may be divided generally into two classes—owners who have sold their property and tenants who have moved. The first class is relatively small, but the bills in individual cases sometimes run to large amounts. The second class consists of a very large number of small accounts, the sum total of which constitutes a sizeable amount.

If the city were to lose all these accounts, the amount lost would have to be made up by increasing the rates now chargeable to consumers. Such a course would, obviously, be unfair, so the problem is that of discovering some method by which the city can assure the payment of all its bills.

Three methods are available. The first is the ordinary one of civil suit to collect at law. This must be ruled out at the start because in most cases the bills are too small to justify litigation and because the possibility of enforcing judgment is not great.

The second method would be to require each consumer to deposit with the city a sum large enough to cover his probable consumption during the collection period. This method is used by a great many privately owned utilities. In the case of a city, the use of this method would require the maintenance of an enormous deposit fund, requiring endless bookkeeping. It would be a nuisance both to the city and to the consumer.

The third plan is the one under which the City of Cincinnati is operating. By this plan, the city enacts ordinances which, on the one hand, make the owners of property responsible for their tenants, and on the other, impose on purchasers of property the responsibility of checking up on outstanding water bills before they take over. Ordinances of this character require that when a bill presented for collection is not paid within the time prescribed, the water shall be turned off and shall not be turned on again until paid. The city would have no power to do this unless there were statutory or ordinance provisions authorizing it. There would seem to be no natural right to refuse service to a landlord or to a new purchaser because the bill of a former tenant or former owner had not been paid.

Objection has been made to this type of legislation on the ground that it is unfair to the landlord and to the new purchaser. At first thought, the complaint would seem to be justified. Once the system is understood, however, no especial hardship arises. The landlord understands that if he wants water for one of his properties, he must assume responsibility for it. He is in a better position to know his tenants than the city is and he has better opportunities of protecting himself against his tenants than has the city.

Again, in the case of the purchaser of property, once it is generally understood that the purchaser cannot be served on a line on which there is a delinquent account, it will be accepted as general practice that he must protect himself when he buys. He can find out whether there is a delinquent bill and protect himself accordingly. So long as he knows beforehand, he need suffer no loss.

The method of holding the service line responsible, that is, of withholding water until the outstanding bill is paid, is the simplest, the fairest and the most effective way of protecting the consumers of water against losses from unpaid bills. It does not require the tying up of useless deposit funds. All that the public needs to know is that the new user of a service line must, before he takes over the line, satisfy himself that there are no charges against it. When he does this, he is protected.

In some states, the law has authorized municipalities to acquire liens for unpaid water bills. The state of Ohio has no such provision. Such a provision would be a help and should be provided by law, but if municipal legislation such as has been suggested is sustained, as the author believes it should be, the lien provision would make little or no difference. The essential thing is the power to withhold service on the consumer's line until the bill is paid.

A 100 Per Cent Meterization Program

By Everitt Robbins

FOR about two years after the municipal water system was installed at Scottsburg, Ind., in 1923, it was 100 per cent metered; but when, at the end of that period, bonded indebtedness forced the curtailment of operating funds, metering was one of the first practices to be discontinued. This was considered justifiable economy because it was felt that with more funds available in the following year, installation of meters could be continued without difficulty. In the following years, however, the financial status remained unchanged and before long the metering problem was entirely out of hand.

The meters already installed were maintained in fair condition and were shifted around so that business places and other large consumers were metered. From time to time, too, a few additional meters were purchased, but there were never enough available to keep pace with the town's growth. During this time, meter yokes or connections were installed on every house service, with the goal in mind that, at some time, enough meters could be purchased to return the system to its original 100-per cent basis. These conditions existed until late in 1940, by which time meterization had been reduced to 25 per cent.

Because each community, due to its local conditions, has a different water problem, it was impossible for the local water works men to convince their governing body of the benefits of metering by comparison with other cities and towns. With the aid of the A. W. W. A. *Manual*, the JOURNAL and the information contributed by meter salesmen, however, data were assembled which definitely indicated the possibilities of realizing economies in operation and conservation of water by the use of meters; and this, after five years of hammering on the subject, finally gained the support necessary. In achieving

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this final approval, estimates, considered to be conservative, of a pumpage decrease of 20 per cent and a revenue increase of 15 per cent were submitted to the Water Board.

Since it required only twenty days to install the meters, results have been readily determinable. The system has now been operating on the 100-per cent meterization basis since November, 1940. During this period pumpage has been reduced 30 per cent as compared with the same period in 1939–40, notwithstanding the 10 per cent growth of service since that time. Average monthly revenue, on the other hand, has increased 10 per cent, and with the heavy consumption months of summer coming, it is believed that the goal of 15 per cent increase for the year will be achieved.

Since the metering of the system was accomplished in a very short time, consumer approval of the project had to be obtained quickly. To accomplish this, the water department succeeded in obtaining the full co-operation of the two local newspapers. In them, an article, by the superintendent, explaining the necessity for meters and stressing the need for conservation of the water supply, was published along with favorable editorial comment. Most of the populace was acquainted with the low capacity of the wells in the area and so was able to appreciate the validity of the appeal.

Consumer Education

When installation of meters began, a handbill and two pamphlets were left at each consumer's residence or place of business. The handbill informed him of the necessity to repair all leaks and to stop all known waste if his bills were to reflect actual use, and the pamphlets (furnished, free of charge, by a meter setting supply company) gave general information concerning the benefits to health and fire protection which obtained from public water supply.

After billings on meter readings had been forwarded to the consumers, a post card was sent to all those whose bills were high. These cards pointed out that the size of the charge indicated a leak which it would be to the consumer's advantage to repair immediately. This practice, it is certain, is what prevented the office from being swamped with check-up calls and complaints.

In addition to the post card, a handbill containing suggestions on the detection of leaks, was also forwarded to these consumers. One section, for example, pointed out that by taking off the lid of the toilet tank and sprinkling talcum or other powder on the surface of

the water, a leak would be indicated if the powder particles moved over to and down the overflow pipe. It is felt that the distribution of such information eliminated a large number of complaints at the source, and that this and the other publicity schemes employed helped to get the job done with the least amount of friction, and that they probably account for the fact that no one openly took issue with the department on its metering project.

It had long been suspected that many plumbing leaks existed throughout the town; and after the first two or three monthly bills had been issued, it was apparent that in almost every building where the plumbing equipment had been in service for three years or longer, the tank toilet fixtures were leaking. The water consumption in these cases ranged from 5,000 to 15,000 gallons per month, and in one unusual case—a six-room double residence—consumption exceeded 120,000 gallons per month, a bill of over $25. After the leak was repaired in this case, consumption decreased to about 5,000 gallons per month.

Observation of operating results indicates that it required three months for daily pumpage to fall to its lowest point. This minimum will probably never be reached again because it was due to the fact that consumers were leak and waste conscious while the publicity was still fresh in their minds, but the fact that daily pumpage was reduced to a point where it did not vary over 15,000 gallons through the week is indicative of the tremendous effect of leaks. Before the publicity program it was not uncommon to have variations of from 30,000 to 40,000 gallons. It is interesting, too, to note that before metering, severe cold weather carried a demand almost as high as a hot dry spell in summer, while during the last winter, consumption in severely cold weather was very little different from that during mild temperatures.

Methods of Handling Sand and Gravel

By M. P. Crabill

THE Indianapolis Filter Plant consists of a 36-m.g.d. slow sand unit and a 15-m.g.d. rapid sand unit. The slow sand section is made up of six filters with 18-inch sand and 12-inch gravel layers. Originally these filters were 200 ft. by 350 ft. in size, with 36-inch sand layers and no roofs; but after a winter during which it was necessary to remove ice, 16 in. thick, before a filter could be scraped, the beds were divided and roofed.

Records of the slow sand plant show that the scraping and wheeling out of $\frac{1}{2}$ in. of sand from a filter required the services of 53 men for $1\frac{1}{2}$ ten-hour days (795 man-hours). The men wore wooden shoes (similar to snowshoes) and used specially designed scrapers. Planks were laid throughout the filter for transporting the sand to storage by wheelbarrows; and to return it at a later date. The complete cost of such scraping was 70 cents per cu.yd.

This method was soon changed, however, so that sand was ejected hydraulically to a washing machine outside the filters. It was then either returned to the filters or ejected to a storage bin until the filter was recharged.

At present, in an average year, more than 12,000 cu.yd. of sand are handled in the slow sand plant alone to maintain the filters in satisfactory operating condition. A filter is scraped to a depth of 1 in. by a crew of six in about six hours, at a cost of 22 cents per cu.yd. The snowshoes have been discarded and the special scrapers replaced by moulders shovels. Scraped sand is no longer ejected but is piled in the filter itself, in rows across the filter between the roof columns. The footings of these columns block the underdrain system so that little of the active filtering surface is lost. Insofar as operating condi-

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tions permit, three 1-inch scrapings are the most that are piled between washes. These pilings are then included with whatever sand is scraped from the filter at the time the unit is washed.

Slow Sand Filter Wash

In 1934, a mechanical scraper-washer, which had served well for 10 years, was abandoned because of its high maintenance cost and the delays in procuring replacements, so filter washing is now done manually. A careful study of the relative costs of the two methods indicates that a slight saving obtains from the manual method. More important, however, the manual method saves several days in the overall time a filter is out of service. This saving results from the use of an extra washing crew with the manual method. Two crews of three men each, starting at opposite ends of a filter and on opposite sides, with each crew washing only to the center line, cut the washing time in half. Each crew, equipped with an ejector and separator, works toward the center, passes in the middle and finishes at the opposite end of the filter unit.

During washing, two men feed the ejector and a third handles the spreading hose. The initial step is to scrape an area of 20 ft. by 50 ft. at each end and to move the separator into this area. The dirty sand is then piled ahead of the area so that the ejector is started ahead of the separator and continues so throughout the wash. The separator wheels ride in a 4-inch channel track made up in 10-foot sections. Two sections are used with each crew so that one is always free to move ahead of the machine, which always rides on clean sand. The ejector works ahead, taking both the sand that has already been piled and the additional scraped sand included in the wash, the sand from the piles being fed into the ejector much more easily and rapidly. From 12 to 15 cu.yd. per hr. of sand are handled in this way at costs varying from 55 to 70 cents per cu.yd.

Design of Ejector

The ejectors were designed by the Company's engineering department. The units are all metal with welded body joints. The prime consideration was to build a unit in which the true alignment between the nozzle and the throat piece could be maintained. Several years experience have proved the value of the rigid construction employed. Although the rate of handling sand has increased in this time, increases in rates of pay for laborers have kept costs at about the same figure.

The ejectors (Figs. 1–3) are operated with water at 90 lb. per sq.in. pressure at the nozzle. The use of the center spray is varied with different washes, depending almost entirely on the amount of dirt in the sand. The hopper sides are sloped sufficiently to prevent sticking and piling on the walls. The hopper capacity is $2\frac{1}{4}$ cu.ft.

A return bend (Fig. 1) on the nozzle end of the ejector brings the pressure supply hose and the discharge hose to the same end. This is a decided advantage when the unit is moved with the hose attached.

The throat piece (Fig. 3) was adopted after several designs had been tried. It has the advantage of handling sand more rapidly than other designs, and of being installed from outside the ejector. The coupling on the sand-carrying hose can be loosened and the new throat piece inserted until it is firm against the inner rim (Fig. 3) of the throat piece collar. The outside end of the throat extends just past the hose coupling. This serves not only to protect the coupling but provides something to grasp if the old piece is difficult to remove. The throat pieces cost 80 cents each and will handle 500 cu.yd. of sand before changing is necessary.

Design of Separator

The separators are not of local design. They are the conventional type in which the sand from the ejector enters the separator near the top and strikes a deflecting plate which scatters it in all directions. The deflecting plate fits between the body of the separator and an apron which extends from the top to about 8 in. above the conical bottom of the unit. The apron is eccentric to provide ample room for the sand on the entering side and a comparatively small space between the body and the apron on the opposite side. The greater portion of the sand is deposited after traveling about half way around the channel. The sand falls into the conical bottom section and from there it is discharged through a 3-inch spreading hose. The dirty water is forced to the top (inside the apron) and then withdrawn to a stilling box. Fine sand which has passed out of the separator is recovered from the stilling box and spread back in the filter. The complete separator weighs less than 400 lb. The ejector weighs 150 lb. and can be handled easily with hose attached by two men.

Rapid Sand Filter Wash

In the rapid filter plant, the sand is usually washed early in the spring, using the same equipment. These filters present no particular washing problem if only the sand is handled.

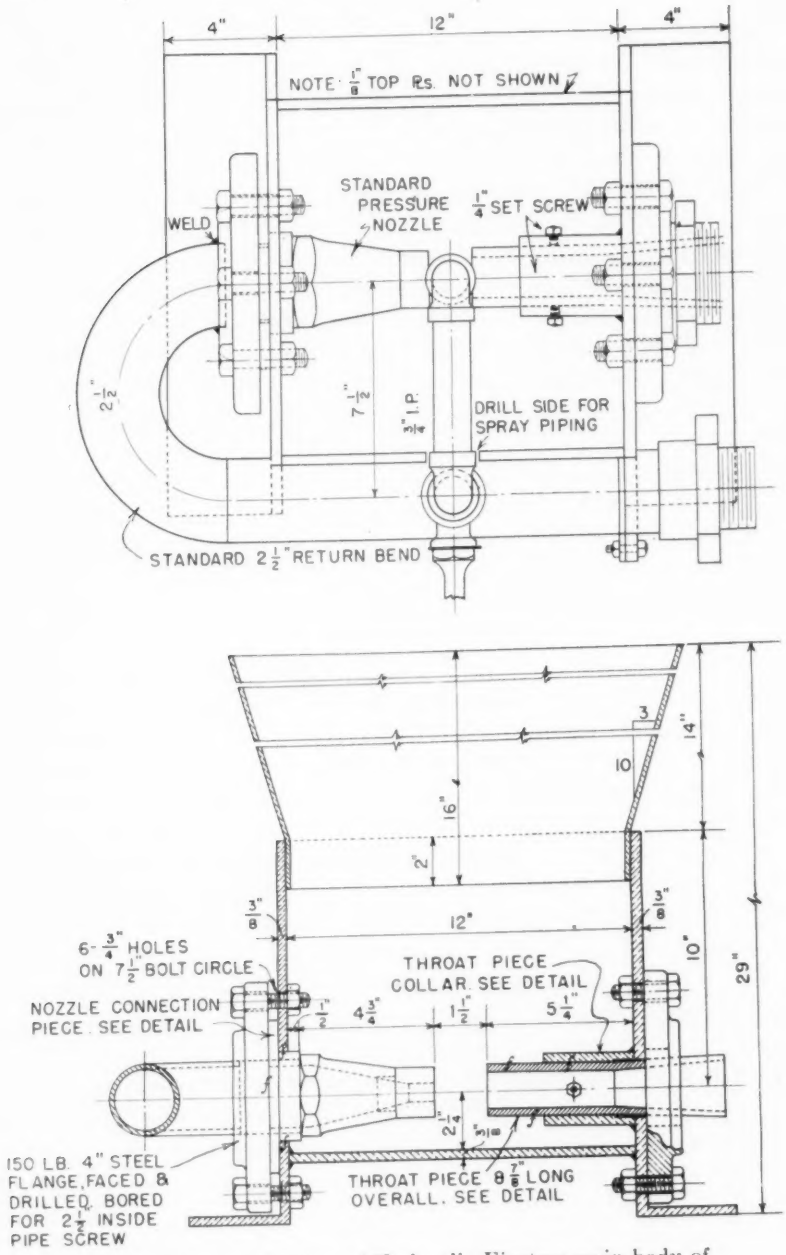


FIG. 1. Plan and Section of Hydraulic Ejector; main body of welded construction

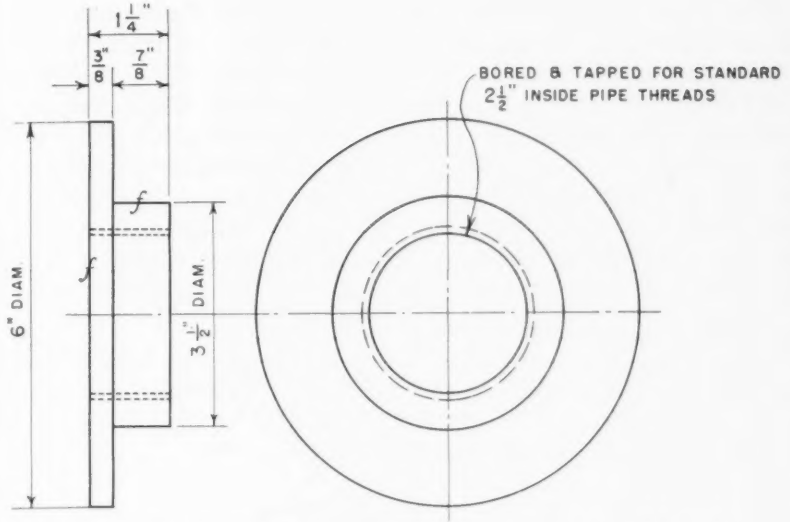
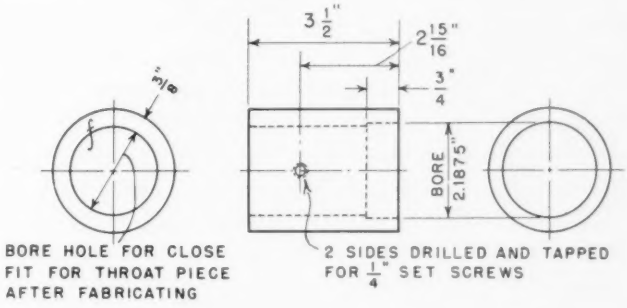


FIG. 2. Detail of Nozzle Connection Piece; material—mild steel



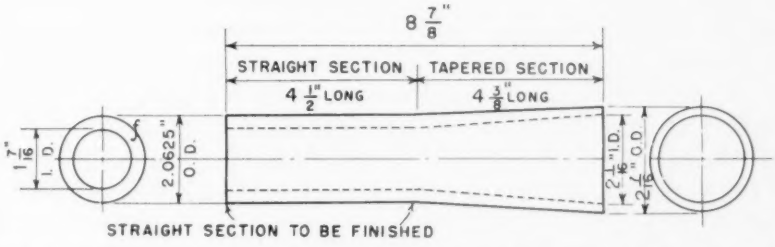


FIG. 3. Detail of Throat Piece and Collar; materials—throat piece, cast iron; collar, malleable iron

Outside the filter building and on the concrete top of an old reservoir several wooden storage bins, of more than sufficient capacity to hold all the sand from one filter, have been constructed. The sand from one filter is ejected to a separator outside the building and from there it is discharged into the storage bins. After all the sand in the first filter is stored outside, that in the adjacent filter is washed through the separator and delivered into the first unit. This procedure follows in order until the sand in each filter has been washed and moved to the one adjacent. The stored sand taken from the first filter is then ejected to the separator, which is placed over the last empty filter, and spread back into that unit.

During this operation two men stand in the filter to feed the ejector, one man controls the separator, which stands on the floor between the filters, while a fourth handles the spreading hose. By this technique, about 70 cu.yd. of sand can be handled in a 7-hour day.

Gravel Wash and Regrading

The rapid filter plant had been in operation for five years when an inspection of the gravel layers indicated that washing and regrading were advisable. A mechanical two-deck grader was purchased and installed outside the filter building near the sand storage bins. Its location required the transportation of the gravel for about 100 ft. from the most distant filter. The lift to the top deck of the grader is 5 ft. above the operating floor level, and from there it delivers the separated sizes into different piles. Gravel of sizes up to and including $\frac{3}{4}$ in. was transported to the top deck of the grader through an ejector which had been especially fitted with a 3-inch pipe nipple as a throat piece. The hose on the outlet side of the ejector was a 3-inch rubber one of the same type as used for sand spreading. To prevent irregular stones from entering the ejector and later lodging crosswise in the hose, a $\frac{3}{4}$-inch screen was fitted over the top of the ejector hopper and in this way many choke-ups were avoided.

The balance of gravel (sizes 1 in. to $2\frac{1}{2}$-in.) was handled inside the filter. One platform covering about a quarter of the filter surface was built on top of the wash water troughs and a second platform of the same size was laid on top of the gravel in the adjacent corner. All gravel remaining in the other half of the filter, except the $2\frac{1}{2}$-inch size between the laterals, was shoveled onto the lower platform, where the $\frac{3}{4}$- to 1-inch size was screened out, by shoveling onto a stationary framed screen, 3 ft. by 5 ft. in size. The stones rejected by this screen

rolled off and were then shoveled to the top platform where the $1\frac{1}{2}$- and 2-inch sizes were separated. All of this gravel was washed by high pressure hosing and hand-brushed when necessary.

The remaining gravel in the half-filter, a layer of $2\frac{1}{2}$-inch stones between the laterals, was then taken out of position and hand-brushed before washing, which was accomplished by hosing small piles of the stones. The lateral perforations were cleaned by reaming with a heavy-gage rod and, finally, the stones were replaced. Other grades of the gravel were shoveled into place and spread out, one grade at a time, until the first half of the filter was completed except for the $\frac{3}{4}$-inch and smaller sizes which were stored outside. The platforms were then moved to the other half of the filter and the procedure repeated. After that the stones stored outside were ejected into the filter, spread and leveled, grade by grade.

The area that can be worked in a filter depends entirely upon the space available for platforms. The many grades to be separated require a great deal more equipment than it is convenient to fit into a filter. Actually, the completion of a single filter requires the handling of approximately 50 cu.yd. of gravel. To complete the operation at the rapid sand plant required 13 days and the cost averaged $5 per cu.yd.

Mud Ball Formation

Production during the high demand season runs approximately 90 per cent of the total plant capacity. As a result of three or four months of continuous operation at high filtration rates the rapid filters become heavily loaded with mud balls. Under these conditions surfaces of the filter crack and mound in many places. Some of the mud balls found were fully as large as a bushel basket. To relieve this condition, all of the filters were washed by the ejector-separator method as soon as they could be taken out of service when production rates fell off early in the fall. The winters' operation usually necessitated another such renovating in the late spring, immediately before the heavy load period began. During the summer such methods as raking the sand and using high pressure hose streams in the lower sand strata while backwashing did not seem to disintegrate the mud balls. Other methods attempted were the use of a small paddle on the extended shaft of an electric drill, sulfur dioxide treatment and high chlorination (as much as 200 p.p.m. directly on the filter). Improvements, if any, however, were so temporary that they were of little consequence.

Installation of Surface Wash

In June, 1939, then, a Palmer surface wash system was installed in six of the rapid sand filters. Each of these filters is 721 sq.ft. in area and has six surface agitator arms. An individual arm has twelve nozzles which discharge through $\frac{1}{8}$-inch orifices. These arms are 10 ft. long, and their rotation sweep covers 65 per cent of the total area (90 per cent when they are discharging). The six arms in one filter use about 375 g.p.m. water at about 100 lb. per sq.in.

Twelve months before the surface wash system was installed the sand was removed from each of the six filters and washed by the ejector-separator method; and seven months before the installation, the gravel in one of the filters was removed, washed and regraded, along with the sand. Of the remaining five filters, the gravel in four had not been touched for five years, and in the other, had been washed and regraded just three years before the agitators were installed. In other words, it is apparent that the installation was not made at a time when the filters were in such good order that they required merely maintenance of condition. With the accumulated mud balls and leaves, the cracking and mounding of the sand and gravel, resulting from twelve months of continuous operation, mostly at full capacity, the filters were badly in need of cleaning. It would seem that even if the surface wash system had failed to bring the filters into better condition, any criticism under such circumstances would not be just.

Mud Ball Determination

For some months previous to June, 1939, a chart record was kept of the location of such mud balls as were found in the filters during the time the sand was expanded. The mud balls were located by feeling for them with an 8-inch square plate riveted to the end of a $\frac{1}{2}$-inch tube. The plate was pushed down to just above the grit level where it was moved about rather slowly in a horizontal plane until it was brought into contact either with a mud ball or a gravel mound. In this way, it was easy to determine the size of the mud ball by moving the plate around its outside edge. By putting the plate in the center of the mud ball and exerting a downward pressure it was easy, too, to differentiate between mud balls and gravel mounds. Because the washing time is only from 5 to 6 min. each filter was covered by sections until all mud balls were spotted and plotted on a chart.

Along with the feeling method, determinations of incipient mud balls were made by a method, described by Baylis (Jour. A. W. W. A., **29:** 1021 (1937)), by which the sand in the top 6 in. of the filter is sampled and mud balls are measured volumetrically. All of the determinations made in this way were found to lie in a range entitled "Bad."

Application of Surface Wash

In the beginning, the practice of using the surface wash was confined to the first 3 min. of a wash, during which time the backwash valve was opened only enough to obtain a very slight expansion of the sand—not more than enough to make the sand fluid and to overflow water to the wash water troughs. The filters were then drained down to the wash water trough level before either the backwash or the surface wash was opened. The surface wash was operated 3 min. with the minimum sand expansion and then shut down while the backwash valve was opened to obtain 50 per cent expansion. Meanwhile the backwash was continued until clear water overflowed to the troughs—usually from 4 to 5 min. in addition to the time the agitators were used.

The results of several months' operation by this method showed that surface cracks and sand mounds were eliminated. The time during which a filter was run to waste after a wash increased with the agitator installation so that 1½ to 2 hr. was lost before the filter could be returned to service. Filters were put into service when the turbidity of the filtered water fell to 0.3 p.p.m. as read on the St. Louis type turbidimeter. The use of wash water increased slightly (about 0.2 per cent) over what it had been before surface wash was installed.

The one filter in which the gravel and sand had been cleaned only seven months before the agitators were installed showed no better effluent than the others, neither producing longer runs nor using less wash water. The mud ball chart was continued and the record indicated that very few of the mud balls had disappeared; and the larger ones neither moved nor decreased in size. The sand surface, however, appeared to be much cleaner and brighter.

After six months, this method of using the surface wash equipment was changed so that it was operated for 1 min. before the backwash valve was opened. The purpose of this minute's operation was to loosen the matted surface and prevent it from cracking and turning over when the backwash was started. The backwash valve was then

opened to obtain 50 per cent expansion of the sand, and surface wash was continued for another 3 min. The object of this change was to permit the agitator jets to play on the larger mud balls just above the grits. Extreme care was exercised to prevent the loss of sand. Cups mounted at 1-inch intervals on a long wooden stick were held at the wash water trough overflow so that the bottom cup extended 9 in. below the top one. If any sand was caught in the cups the backwash rate was cut. The cups were submerged and withdrawn for inspection at each backwash rate. Even with this precaution, however, later inspections (when the filters were drained) indicated that sand had been lost.

About 1 months' operation with this method showed conclusively that mud balls had become fewer and smaller. Some of the smaller ones had disappeared completely; and in another two months, only two mud balls could be located, and they were small in contrast to their original size.

Prevention of Algae Troubles

During the final breakdown of these last mud balls, higher summer rates and algae troubles began. Overnight, filter runs dropped from 30 to about 2 hr. Algae cemented the top sand of the filter so that a $\frac{1}{2}$-inch rod could not be pushed down hard enough to penetrate it. The predominant organism at the time was *Melosira*, and total counts going to the filters were about 7,000 per ml. A drain-down inspection of one filter led to the finding that only the top $\frac{1}{8}$ in. of sand had hardened and that when this was scraped off, clean and soft sand was exposed. Experimentally, the surface wash was turned on for 2 min. while the filter was standing full. Then, while the material which had been stirred up by the agitators was still floating, the drain valve was opened and the water wasted to the level of the wash water troughs, the backwash not being used at all. This operation required 5 min. and the filter effluent turbidity was 0.2 p.p.m. or less when returned to service immediately after refilling.

The results of the experimental wash seemed to warrant the continued use of the method so long as runs were short. Eventually the method was used two times between normal backwashes. In 95 per cent of the occasions in which it was used, it returned the filters to service at 0.3 p.p.m. or less turbidity and within 10 min. of the time when they were taken out of service. Many hours of lost service as well as several million gallons of water were saved, and the

quality of the filter effluent was maintained. During its use, raw water turbidities were about 5.0 p.p.m. and settled water turbidities, at 1.0 and 1.5 p.p.m.

It may seem that such a method of surface wash might defeat the purpose of the agitators by permitting a greater penetration of the material which is normally collected at the surface and removed easily during backwashing. There was no evidence to substantiate such reasoning, however, as no new mud balls were formed and the remaining ones did not enlarge.

After such a wash the filter surface was well covered with ridges and valleys. The section immediately under the agitator arm was in the shape of a hollow cone with the maximum depression at the center, probably 4 to 5 in. below normal sand level. This left 25 to 26 in. full depth of sand in the shallow sections. Normal washes during the same period were continued with 50 per cent expansion while the agitators were working.

General Observation on Use of Surface Wash

At the beginning of the late winter season of 1940, the filters were found to be entirely free of mud balls. The excellent sand cleaning made it hopeful that even gravel layers might show some signs of improvement. An inspection of the gravel in two filters indicated that there had been no effective cleaning beneath the grits. It should be pointed out, however, that, with the exception of one filter, the gravel was not clean when the system was installed, and that, so far as is known, no statement or claim has ever been made either by the designer of the method or any of its users to the effect that it can clean gravel layers. From the experience at Indianapolis, however, it seems logical to expect that the gravel could be maintained in a clean condition if at the time of installation both sand and gravel were clean.

Recent measurements on sand levels indicate that during the first 20 months with surface wash, about 3 in. of sand have been lost from each filter unit. Some users, who have noted a shrinking in the sand unit after installations, believe it to be entirely due to the loss of sand coating. This may be true in some instances, but in this case sieve analyses made during the past four months show no appreciable difference from those made before the installation. The knowledge that sand was being lost brought about still another change in the method of using the agitator. Starting in December, 1940, it became

standard practice to use the surface wash for a 2-minute period after the filter was drained down to within 6 in. of the sand level. During this period, the backwash valve is cracked sufficiently to admit only enough water to bring the level to the trough overflow. Surface wash is then discontinued in favor of the normal backwash.

Since the date of this innovation, no new mud balls have appeared. The period, however, has been one during which any desired degree of expansion could be obtained and during which the raw water carried but few algae. The summer months may require a return to the method which proved effective in removing the mud balls.

The filter plant is not equipped with fine screens on the raw or settled water conduits, so a great many leaves travel through the settling basins and enter the filters. Certainly such a factor increases the job which surface wash and backwash must do. Removal of the leaves would permit a more uniform rise of wash water and, consequently, better washing results. The only condition which bears evidence that leaves are likely to contribute any trouble is that they have been found in the grits and that, where they are the most abundant, the grits are mounded.

The cost of repairs and maintenance to the surface wash system has been less than $10 for the 20 months of operation. The results seem to bear evidence that the system has proved very effective in keeping filter sand clean and in eliminating mud balls, when used with sufficient expansion to permit penetration of the surface wash water. Since the beginning of 1941, the use of wash water has fallen off very slightly, about 0.1 per cent, as against an increase of 0.2 per cent during its early use.

Operation Problems in the New Wichita Water System

By M. E. Rogers

NUMEROUS papers have appeared in the various technical and trade publications (1, 2, 3, 4) describing the new water supply facilities recently constructed and placed in service by the City of Wichita, Kan. To date (March, 1941), this system has been in operation for slightly more than six months, and as might be expected, various operating problems involved in the substitution of practice for theory have arisen. Several of these problems have not as yet been solved to the satisfaction of all concerned; some have been eliminated or adjusted satisfactorily; others are in the process of solution. The remarks to follow, therefore, must be qualified as being in the nature of a progress report rather than a final evaluation.

Selection of Personnel

The first problem encountered was one of securing adequate experienced or qualified personnel with which to staff an organization of this size and importance. The City of Wichita had not previously been in the water business and so had no nucleus of old and faithful employees on which to build. The city operates under the city manager law which provides, among other things, that "all employees shall be selected on the basis of merit and fitness alone." Starting from this basis, the matter of the new positions to be created and filled was given wide publicity, not only locally, but nationally. Hundreds of applications were received for the various positions offered. Meanwhile, numerous persons and agencies were consulted with regard to qualifications and means of examining and selecting the best possible applicants from the mass of applications considered.

A contribution by M. E. Rogers, Superintendent of Production, Municipal Water Supply Plant, Wichita, Kan. This article is part of a paper delivered by the author before the Kansas Water and Sewage Works Association in March, 1941.

Accordingly, a set of examinations was evolved covering the several positions offered; specifications and qualifications were set up and sent to each applicant, together with formal application blanks. The qualifying examinations were taken by all applicants under the supervision of Dr. Hugo Wall, head of the political science department of the University of Wichita. The examinations were graded and the candidates rated on the basis of their papers by various professional committees appointed for the purpose. Each applicant was assigned a number upon entrance to the examining place and lost his identity until the rating and grading were complete. The high ranking candidates were then certified to the city and final elimination was made on the basis of personal interviews, conducted for the most part by the members of the rating committees, except that the city appointed a representative to sit in on the interviews.

As a result of this procedure, qualified employees were secured; the city was enabled to establish an eligible list for future positions with a minimum of effort, and all candidates were assured of a fair opportunity to secure the positions. Weight was given in the final selection to local applicants, provided, of course, that their qualifications and examinations were equivalent to out-of-town or out-of-state applicants.

Control of Well Supply

Of the 25 supply wells in the Wichita Supply System, no two have the same mineral content. When it is considered, however, that these wells intercept a 13-mile ground water front, this fact does not seem in the least unusual. Some of the characteristics of the hardest well, the softest well and the average of all wells, are as follows:

WELLS	HARDNESS	ALKY.	EXCESS ALKY.	Cl	Ca	Fe	Mn
	p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*
Softest	115	133	10	6.5	36	0.05	0.06
Hardest	250	269	74	75.0	77	2.80	0.35
Average	161	200	39	29.0	50	1.04	0.29

The well pump columns vary from 53.6 to 113.4 ft. in length and the motors powering the well pumps vary in size from 10 to 40 h.p. It may readily be seen that numerous factors govern the operating

procedure for the various well units. For example, it is possible to operate continually those wells having the lowest hardness values or those drawing the lightest power load from the standpoint of economy, or to vary the well operation to secure a uniform mineral content of the raw water supply.

The well field lies in the midst of a prosperous agricultural area. Extreme caution has been necessary in distributing the pumping to prevent excessive drawdown in the vicinity of any well so that adjacent farm wells will not go dry.

Actually, a combination of all three methods has been followed. First, all units are required to operate the same number of hours over a given period of time, thus equalizing wear and obsolescence. Combinations of wells which provide a predetermined mineral content in the raw water and for a given flow are determined; and then consideration is given to economy of operation for the various combinations possible. This plan has worked out very successfully thus far, but it entails considerable supervision for proper control.

Coagulation Experiments

Before starting the new plant, certain preliminary tests were made in the laboratory and by the data thus obtained the chemical feed machines were adjusted and the water plant placed in operation. Needless to say, there was room for improvement. First, the water was extremely difficult to coagulate, a large excess of floc being carried to the filters. Tests were set up and coagulating properties of several chemicals commonly used for coagulation were investigated. The water did not contain sufficient suspended matter to weight down the floc efficiently. This immediately suggested a heavier type of coagulant, such as one of the iron compounds. Some of the preliminary tests employing various coagulants gave results as follows:

COAGULANT	DOSAGE	OBSERVED FLOC	SUPERNATANT OR VOIDS
Alum (Standard)	0.4	fair	smoky
Alum (Ajax)	0.4	fair	smoky
Ferrous Sulfate	0.4	good	clear
Ferrisul	0.4	good	clear
Ferri Floc	0.4	good	slightly smoky
Sodium Silicate (.20)	—	—	—
Alum (.20)	—	poor	—

Upon the basis of this preliminary study, a series of tests to determine the flocculating properties of ferrous iron salts as compared with alum was carried out. Table 1 is a tabulation of laboratory jar tests from which a plant scale treatment was finally decided upon. This table shows clearly the improved efficiency that might be expected by the reduction of hardness with iron salts as compared with the aluminum salts, and the possible resultant saving of chemicals with the Wichita water. Until now, no attempt has been made to oxidize

TABLE 1

*Results of Analyses of Finished Water After Various Chemical Dosages**

DOSAGE			TREATED WATER		OBSERVED FLOC	SUPERNATANT OR VOIDS
CaO	Alum	Ferrous Sulfate	Alky.	Hardness		
g.p.g.	*g.p.g.*	*g.p.g.*	*p.p.m.*	*p.p.m.*		
2.0	0.2		182	130	smoky	milky
2.0	0.3		180	128	good	fairly clear
2.0	0.4		178	130	good	fairly clear
2.0	0.5		178	131	fair	slightly milky
2.0	1.0		172	130	poor	very milky
2.0		0.2	167	118	good	fairly clear
2.0		0.3	166	117	excellent	clear
2.0		0.4	167	119	good	clear
2.0		0.5	166	118	fair	slightly milky
2.0		1.0	166	118	poor	milky
1.7		0.3	180	126	good	clear
2.0	0.3		180	126	good	clear

* Raw water characteristics: total hardness, 154 p.p.m.; total alkalinity, 204 p.p.m.; iron, 0.6 p.p.m.

the iron by the use of chlorine. The water from the aerators is saturated with oxygen and the lime is added before the chlorine so that all reactions are apparently complete. No increase in chlorine demand through the plant has been noticed with the ferrous salts.

Table 2 shows operating results on a plant scale, using a raw water of controlled characteristics, from November 30, 1940, to January 16, 1941, inclusive, or 48 days on alum, and from January 17, 1941, to February 26, 1941, inclusive, or 41 days on ferrous iron.

Some consideration was given to the sequence with which the vari-

ous chemicals were added, and studies were made using different ratios of alum and ferrous sulfate together, as proved successful at St. Louis (5). Typical laboratory studies covering this phase of the

TABLE 2

Efficiency of Coagulants on Plant Scale Treatment

WATER TREATED	DOSAGE			HARDNESS OF WATER			WATER FILTERED PER FOOT LOSS OF HEAD	COST OF LIME AND COAGULANT PER MIL.GAL.
	Lime	Alum	Ferrous Sulfate	Raw	Finished	Softened		
mil.gal.	*g.p.g.*	*g.p.g.*	*g.p.g.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*mil.gal.*	
424	1.99	.31		151	124	27	1.26	$2.02
362	1.65		.32	150	125	25	1.76	$1.73

TABLE 3

*Data on Use of Mixed Coagulants and Changing Points of Application**

DOSAGE			TREATED WATER		OBSERVED FLOC	SUPERNATANT OR VOIDS
CaO	Alum	Copperas	Alky.	Hardness		
g.p.g.	*g.p.g.*	*g.p.g.*	*p.p.m.*	*p.p.m.*		
2.0	.27	.13	177	137	good	slightly smoky
2.0	.20	.20	176	136	good	fairly clear
2.0	.13	.27	172	132	excellent	clear
2.0	.10	.30	171	131	excellent	clear
2.0	.08	.32	169	130	good	clear
		Lime Added Before Coagulant				
2.0	0.4		180	138	good	fairly clear
2.0		0.4	170	128	fair	fairly clear
		Coagulant Added Before Lime				
2.0	0.4		180	138	good	fairly clear
2.0		0.4	170	128	good	clear

* Raw water characteristics: total hardness, 162 p.p.m.; total alkalinity, 206 p.p.m.; iron, 0.4 p.p.m.

investigation are shown in Table 3. A ratio of 1 to 3 parts of alum and ferrous sulfate respectively is being tried out on a plant scale at the present time. It is too early as yet to report the results of this method.

That overall plant efficiency has been improved may be seen by reference to Fig. 1, which shows the relationship between amount of water filtered and time, using monthly averages from the filter records. Wash water consumption has steadily decreased, from 1.24 per cent during October, 1940, to 0.73 per cent of water treated during February, 1941.

Filter Maintenance and Operation

It has been possible to operate the filters up to a 9.5 ft. loss of head without sacrificing the rate of filtration or the carrying through of turbidity. Some difficulty was experienced, however, by packing of the sandy surface and the accumulation of calcium carbonate and floc, forming dense masses which were resistant to removal by the wash water velocities used. Wash water is supplied at a rate suffici-

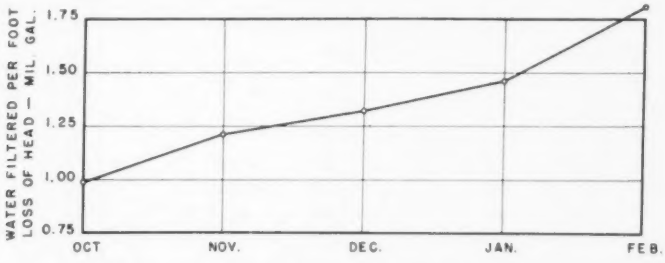


FIG. 1. Effect of Improved Coagulation on Filter Operation

ent to secure a 45 per cent sand expansion, this proving to be the most satisfactory rate. By washing the filter surface to break up the mat, it has been found possible to maintain the sand in excellent condition. No cracking of the sand surface, drawing away from the filter walls, nor mud-ball formation have been observed. A slight reduction in alkalinity is noticed in passing the water through the filters, but no noticeable growth of the filter sand has been apparent up to this time.

Stability of Treated Water

In the original scheme of operation it was contemplated that a chemically stable plant effluent would be produced by the proper adjustment of the pH and calcium carbonate saturation value. All of the hardness present in the supply is in the carbonate form, composed principally of calcium bicarbonate. In addition to this hardness, an excess of 40 p.p.m. sodium and potassium bicarbonates

is present. The raw water leaving the aerator contains 4 or 5 p.p.m. free carbon dioxide and has a pH of from 7.90 to 7.95; while the calcium carbonate stability test requires that the water have a pH of about 7.8. On the basis of alkalinity there was an average loss of 8 p.p.m. as indicated by the stability test, and this amount would have built up a fine protective coating of calcium carbonate quickly, provided, of course, that it did not first stop up all the services and meters. The situation was remedied, however, by increasing the

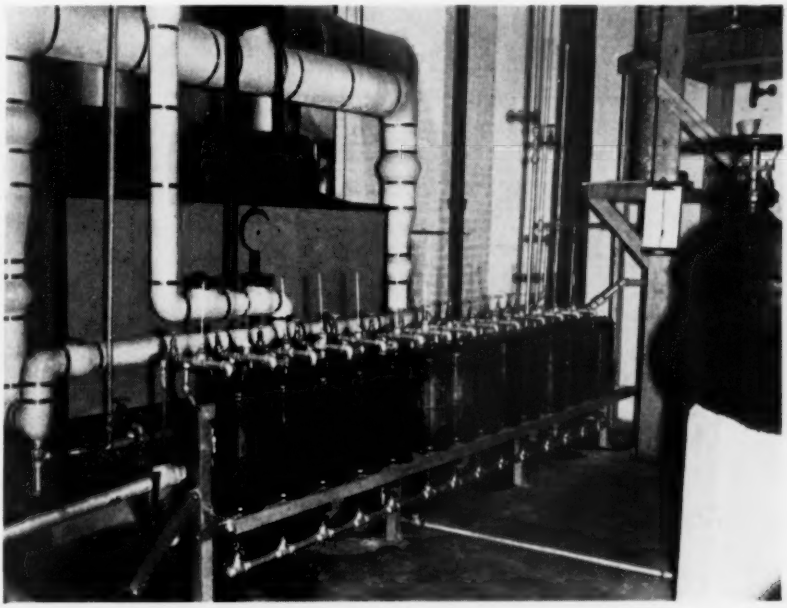


FIG. 2. Hot Water Heater Assembly for Experiments on Effectiveness of Sodium Hexametaphosphate Treatment

lime feed until a new equilibrium point was reached at a pH of about 8.18; and this has resulted in the feeding of between 1.6 and 2.0 g.p.g. lime to secure reductions in hardness, in the effluent, of between 25 and 30 p.p.m.

Treatment With Metaphosphate

After the plant had been in operation for about 90 days, plumbers began to complain about the stopping up of hot water heater coils and hot water lines—in some cases in about 30 days of using the new

supply. It was believed by some that the scale in the mains, which had been deposited by the old water was being dissolved by the new supply. From the first week of plant operation, however, the effects of heat upon the bicarbonate alkalinity had been observed. The excess alkalinity present was not encouraging, since the presence of this additional bicarbonate iron tended to force the precipitation of calcium carbonate when heated. On December 20, 1940, therefore, apparatus for feeding sodium hexametaphosphate was installed and placed in operation. The original dosage fed was 2 p.p.m. This feed was maintained for 30 days and reduced to 1 p.p.m. and finally to 0.5 p.p.m. at 30-day intervals. Prior to installing the metaphos-

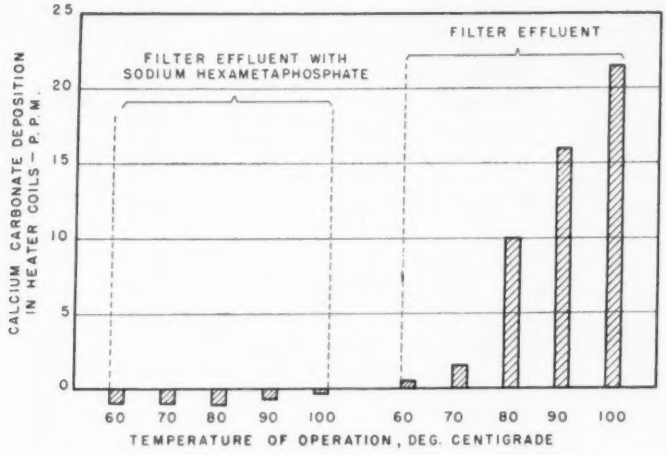


FIG. 3. Comparison of Calcium Carbonate Deposited at Various Temperatures

phate feed, a number of sampling points in hot water systems about the city, in hotels, restaurants, apartments and private homes, were established. Samples were collected every two hours, for 24 hours a day wherever possible. One sample of cold water and one sample of hot water were taken; and the temperature of the water leaving the heater coil was recorded.

These heater sampling points were used to observed the effectiveness of the treatment. Within two days after the feeding of the metaphosphate was begun the effects were apparent throughout the system. Within a week alkalinity drops through the heaters had stopped and, at the 2-p.p.m. feed, one restaurant heater which was

operated, at times, at as high as 128°C., ceased to clog up every three weeks.

To study the problem further, fifteen "sidearm" hot water heaters were arranged in the basement of the plant (Fig. 2); five units operating at various temperatures being fed with treated city water; five with plant effluent, without the metaphosphate; one, with raw water; and three, with water from a small scale treatment plant whose effluent was maintained at 85 p.p.m. total hardness and containing 0.0, 0.25 and 0.50 p.p.m. metaphosphate, respectively. These tests are still under observation. The alkalinity drop through the five heaters operating on stabilized city water and the five operating on unstabilized plant effluent is shown in Fig. 3.

In closing, it should again be pointed out that the discussion here has been merely a report of progress in the solution of the various problems which have arisen in the first months of operation of the new plant. The conclusions drawn are not final, nor is the enumeration of problems to be considered complete. The discussion should, however, serve to point out some of the difficulties which may be impossible to account for before actual operation of a plant is initiated. Much credit for the working out and interpretation of results contained in this article is due Robert H. Hess, Chief Chemist of the Wichita plant.

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Should Larger Portions of Water Be Tested for Coliform Bacteria?

By Ralph E. Noble

AS MOST water works men know, the Treasury standard for safe drinking water on interstate carriers provides that not more than one organism of the coliform group shall be present in 100.0 ml. of water. The present standard practice, of course, is to test at least five 10.0-ml. portions of finished water for control purposes. One positive tube in a series of five, however, yields an index of approximately 2.0 instead of 1.0 per 100.0 ml.

Many who are responsible for maintaining a safe drinking water supply, and those who are concerned with standards of control, naturally feel that if 100.0-, 500.0- or perhaps 1,000-ml. samples could be tested, it would increase the chance of detecting contamination and make it possible to evaluate the water with indices of *less* than 1.0 per 100.0 ml., e.g., 1.0 per 1,000 ml. Experiments have been made in the laboratories of the Chicago Health Department to determine the practical value of such a technique. As less than 35 experiments with 100.0-, 50.0- and 10.0-ml. portions have been made, the work can hardly be considered more than exploratory. Nevertheless, the considerable amount of information afforded by the results seemed to justify making them available at this time.

Briefly, the procedure of the experiments was as follows. Believing it would be of statistical advantage to test 3 liters of water in parallel, ten 100.0-ml., twenty 50.0-ml., and one hundred 10.0-ml. volumes of double strength standard lactose broth were inoculated with equal volumes of test water. The latter consisted of raw Lake Michigan water, the coliform content of which was low or zero as determined by overnight direct plate counts with brilliant green lactose bile agar (1). To $3\frac{1}{2}$ liters of the water, held in the refrigerator, were

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added *Esch. coli* in pure culture to give an approximate content of 0.1, 0.4, 0.7, or 1.0, etc., per 100.0 ml. as desired. If the raw water coliform content was too high, the test water was sufficiently diluted with sterile distilled water, buffered at the same pH, to give coliform concentrations as above.

Having thus prepared the inoculum, it was immediately added to the medium by planting one 100-ml., two 50-ml. and ten 10-ml. volumes alternately and then reversing with ten 10-ml., two 50-ml. and one 100-ml. volumes until all portions were planted. In this way any change in bacterial population was spread over the entire dilution series.

After 24 hr. (about 20 hr. in most cases) incubation at 37°C., transfers from portions showing gas were made to eosin methylene blue agar (E.M.B.) plates and into 2 per cent brilliant green bile lactose (B.G.B.) broth. The coliform procedure was carried through the completed test in the usual way. Growth from B.G.B. tubes showing gas were transferred to E.M.B. agar and the standard procedure completed as above.

After 48-hour (about 44 hr. in most cases) incubation, the same confirmatory tests were again applied to the presumptives as above. Thus, in each experiment, 3 liters of water were examined. The number of portions found positive for coliform organisms in each group, either by the standard procedure or with B.G.B. in the confirmatory position, provided the basis for the index of the given group or dilution.

Results of Experiments

Table 1 illustrates the results from one experiment. Comparisons may be made: (1) on the basis of 24 or 48 hr. or on the combined incubation periods; (2) according to the size of test portion planted; and (3) between the indices by standard procedure and those with B.G.B. broth confirmation.

After consolidating all values obtained at each point from the 22 experiments, the means were drawn and tabulated in Table 2. There it is seen that the standard procedure yields considerably higher values than B.G.B. broth in the confirmatory position (also checked by the *Standard Methods* procedure) on the basis of 48 hr. or on the combined 24–48-hour incubation periods.

The more significant relationships in Table 2 are those of the indices to each other according to the size of test portion. Of particular interest are the combined 24–48-hour values obtained with the stand-

ard procedure. In Table 3 are tabulated all the values on this basis, and in the order of magnitude of those from the 10.0-ml. portions. In order to bring out the effect of increased coliform content on the magnitude of index, according to size of test portion, the data are separated into four groups.

TABLE 1

Typical Results From One Experiment

MEDIUM	37°C. INCUBATION PERIOD	NUMBER AND SIZE OF TEST PORTIONS					
		Ten 100.0-ml.		Twenty 50.0-ml.		One Hundred 10.0-ml.	
		No. Positive	Percentage	No. Positive	Percentage	No. Positive	Percentage
	hr.						
Lactose	24	1	10	2	10	3	3
	48	2	20	5	25	6	6
	24–48	3	30	5	25	6	6
B.G.B.	24	0	0	2	10	1	1
	48	2	20	3	15	2	2
	24–48	2	20	3	15	3	3

TABLE 2

Consolidated Results From 22 Experiments

MEDIUM	37°C. INCUBATION PERIOD	NUMBER AND SIZE OF TEST PORTIONS					
		Ten 100.0-ml.		Twenty 50.0-ml.		One Hundred 10.0-ml.	
		No. Positive	Percentage	No. Positive	Percentage	No. Positive	Percentage
	hr.						
Lactose	24	3.4	34	4.3	22.5	8.2	8.2
	48	4.2	42	7.5	37.5	13.3	13.3
	24–48	5.3	53	8.1	40.5	14.4	14.4
B.G.B.	24	3.3	33	4.3	21.5	6.5	6.5
	48	3.8	38	5.8	29.0	8.7	8.7
	24–48	4.2	42	6.4	32.0	9.6	9.6

It is seen that as the mean coliform positives from 10.0-ml. portions increase, the number and percentage of positive portions by 100-ml., 50-ml. and 10-ml. volumes increase. Hoskins and Butterfield (2, 3) have shown that any group of test portions, of the same size, measures coliform densities most accurately when half the portions are positive and half are negative, and that, as the number of positive and nega-

TABLE 3

24–48-Hour Standard Method *Indices in Order of Magnitude of Those From 10.0-ml. Portions*

EXPERIMENT NO.	NUMBER AND SIZE OF TEST PORTIONS						PERCENTAGE RELATIONSHIPS			MEAN M.P.N.* PER 100.0 ML.		
	Ten 100.0-ml.		Twenty 50.0-ml.		One Hundred 10.0-ml.							
	No. Positive	Percentage	No. Positive	Percentage	No. Positive	Percentage	100-ml. Portions	50-ml. Portions	10-ml. Portions	100-ml. Portions	50-ml. Portions	10-ml. Portions
10	0	0	2	10	1	1						
6	2	20	2	10	2	2						
5	3	30	5	25	4	4						
19	2	20	5	25	4	4						
7	3	30	5	25	6	6						
Total	10	100	19	95	17	17						
Mean	2	20	3.8	19	3.4	3.4	20.0	19.0	3.4	0.23	0.43	0.34
9	6	60	2	10	6	6						
11	6	60	7	35	7	7						
1	4	40	6	30	9	9						
12	3	30	5	25	9	9						
22	6	60	10	50	13	13						
3	5	50	16	80	13	13						
Total	30	300	46	230	57	57						
Mean	5	50	7.7	38.5	9.5	9.5	50.0	38.5	9.5	0.72	1.06	0.99
21	9	90	5	25	14	14						
8	7	70	9	45	15	15						
4	8	80	10	50	16	16						
18	4	40	7	35	17	17						
13	10	100	13	65	18	18						
Total	38	380	44	220	80	80	(70.0)	(38.8)	(15.5)	1.40	1.00	1.68†
Mean	7.6	76	8.8	44	16	16.0	76.0	44.0	16.0			
15	2	20	3	15	19	19						
16	0	0	6	30	22	22						
14	9	90	15	75	24	24						
2	8	80	13	65	25	25						
17	9	90	15	75	25	25						
20	10	100	17	85	47	47						
Total	38	380	69	345	162	162	(70.0)	(52.0)	(23.0)	1.39	1.73	2.60†
Mean	6.3	63	11.5	57.5	27	27.0	63.0	57.5	27.0			
Total All Items	116	1160	178	890	316	316	(48.0)	(37.0)	(12.6)	0.83	1.09	1.33†
Mean	5.3	53	8.1	40.5	14.4	14.4	53.0	40.5	14.4			

* Most probable number.

† Values of Experiments 13 and 20 omitted because M.P.N.'s from ten 100-ml. portions in these series are indeterminate.

tive portions departs from this 50-50 ratio, the group becomes less accurate as an instrument of measure. It is to be recalled that the present standard for drinking water control allows 10 per cent of the aggregate 10.0-ml. portions to be positive for the coliform group. This represents an allowable index (most probable number (M.P.N.)) of 1.05 per 100.0 ml.

Looking at the mean coliform M.P.N., 0.99 per 100.0 ml. by 10-ml. volumes in Table 3, it is seen that 9.5 per cent of the latter and exactly 50 per cent of the 100.0-ml. portions were positive. Thus, the data show that, at the mean coliform level of 0.99 per 100.0 ml., the number of positive 10.0-ml. portions falls within the allowable limits and, at the same time, the 100.0-ml. portions, half positive and half negative, serve their purpose with the maximum expected accuracy. Also it works out, in these data, that the 50.0-ml. portions appear to measure coliform indices most efficiently near 2.6 per 100.0 ml. by 10-ml. volumes.

Regarding the factor of competition between extraneous bacteria and coliform organisms generally, there is greater opportunity for this to occur in water that has been chlorinated but not filtered, such as the Chicago supply, than in one which has been filtered and then chlorinated. Though fewer in actual numbers, the carry-over ratio of anaerobic growth to vegetative forms might be much greater in a filtered-chlorinated effluent than in water that has received only chlorination. The effect of other bacterial growth on coliform organisms in the same culture tube, generally, should tend to reduce the coliform number by overgrowth mechanism. A number of experiments were made with a pure culture of *Esch. coli* in sterile dilution water, buffered at the same pH as that of the raw water experiments, in a range of less than 1.0 per 100.0 ml. Unfortunately the results are too few for proper comparison and dependable conclusions. It is possible, therefore, that the values by 100.0-ml. portions in Experiments 15 and 16, Table 3, *may* be lower than normal because of "overgrowth" by other bacteria.

Discussion of Results

In these experiments, three sizes of multiple portions have been tested and each size separately evaluated, according to the number of portions positive, and then compared with each other. This procedure can introduce the effect of error associated with any group of test portions used to measure coliform densities; so account should be taken of the limitations and inequalities involved.

Reference to Table 4 illustrates the point that each group of test portions, of a given size, is limited in its capacity to measure; also, that their effective ranges overlap. As already mentioned, and as will be illustrated later, the point of most reliable measure is where half the number is positive and half negative. The point of least reliability is at the ends of these ranges where only one portion is positive, in each case. Thus, one 100.0-ml., one 50.0-ml., and one 10.0-ml. portions are equivalent respectively to 0.22, 0.44 and 2.2

TABLE 4

Ranges of Indices (M.P.N.) per 100.0 ml. According to Number and Size of Test Portions When One or More Portions Are Positive

NO. OF SAMPLES	SIZE											
	ml.											
		(1)*		(2)	(3)		(4)					
5	100	0.22		0.51	0.92		1.60					
			(1)			(2)		(3)	(4)			
5	50		0.44			1.00		1.80	3.20			
									(1)	(2)	(3)	(4)
5	10								2.2	5.1	9.2	16.0

* Numerals in parentheses represent number of positive portions.

TABLE 5

Indices M.P.N. per 100.0 ml. as Derived From Three-Dilution Series of 5 Portions Each, Illustrating Index Magnification by Low Percentage of Positive Portions

FIVE PORTIONS EACH OF			NO. OF PORTIONS POSITIVE			INDEX PER 100.0 ML.	NO. OF PORTIONS PLANTED	NO. OF POSITIVE PORTIONS	PERCENTAGE POSITIVE PORTIONS
ml.	*ml.*	*ml.*							
10.0	1.0	0.1	5	4	3	280	15	12	80
1.0	0.1	0.01	4	3	0	270	15	7	47
0.1	0.01	0.001	3	0	0	780	15	3	20

coliform organisms (M.P.N.) per 100.0 ml. of sample. These figures illustrate the *inequality* of values derived from a small number of positive portions in groups under comparison.

Another illustration is provided in Table 5. There it is seen that when an index is derived from a *small* percentage of positive portions it is grossly magnified in relation to the truer index. Also it is seen that the truer value, or index, is associated with nearly equal numbers of the positive and negative 1.0-, 0.1- and 0.01-ml. portions.

The above considerations appear to indicate the propriety of using the size of test portion most appropriate for the coliform level concerned. For example, 100.0-ml. portions seem best suited for coliform densities near 1.0 per 100.0 ml. of sample and, in this connection, certain comments may not be out of order. The use of five 100.0-ml. portions, instead of five 10.0-ml. portions, on finished water, makes it possible to know when coliform densities *approach* the level of 1.0 per 100.0 ml. Without other portions tested in parallel, three 100-ml. portions (60 per cent) give an index (M.P.N.) of 0.92 per 100.0 ml. It is not necessary to test still larger portions when the actual density is less than 0.92, or smaller portions when it is higher, in an attempt to obtain an equal number of positive and negative portions under these conditions. An operator might, however, wish to test a number of small portions of the unfinished water to facilitate control of the final effluent. Under the present standard, one positive 10.0-ml. portion yields an index of 2.2 M.P.N. When that occurs, the actual density of coliform organisms has not only approached but presumably has exceeded the standard of 1.0 per 100.0 ml. With five 100-ml. portions, one, two or three positive portions warn that the density is increasing, soon enough to do something about it before it reaches 1.0 per 100.0 ml. To make a direct comparison of 60 per cent (3) of five 100.0-ml. portions with 20 per cent (1) of five 10.0-ml. portions leads to confusion and misunderstanding because the Treasury standard is expressed in terms of most probable numbers rather than by the Phelps Index.

The objective in this work has been to discover what results may be expected when portions larger than the standard 10.0 ml. are examined for coliform organisms. By making the findings available, the author feels that others may become interested enough to study the problem, or some particular phase of it, further, and that thinking along these lines may be stimulated.

The greater part of the technical work in the experiments herein described was performed by Edward J. Molloy and Viggo T. Miller.

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Fundamentals of Corrosion

By G. W. Gleeson

FOR the purpose of this writing, it appears sufficient to define corrosion as "the chemical action of environment which results in deterioration or destruction beyond the limit of usefulness." In general, corrosion of iron and steel is indicated with particular reference to services buried underground. Within these limitations, a vast bulk of information has accumulated, and it would be impossible to review even a minor portion of it. Perhaps reference to the Bibliography (p. 1260) will serve those who wish to extend their knowledge of the subject. Peculiarly enough, the inexorable quality of nature manifests itself in the corrosion phenomena. We extract metal from the ores of the earth which are in a state of maximum stability with respect to their environment. We return the metal to the earth in the form of services and expect a stability which cannot be; otherwise, the metal would originally have existed in pure form rather than in combination with other elements as ores. Logic dictates that since we must have the metal in a relatively pure form, the only means by which we can prevent the return to the more stable ore is by alteration of the environment in such a direction as to favor stability of the metallic state. Such alteration may take the form of primary protection to shield the metal from natural action, or, conversely, certain of the more active natural actions may be removed or definitely restrained.

In the above rather simple terms exists the fundamental basis of corrosive action. We are opposed to nature and must deal in terms of the customary large number of variables imposed by natural processes. It would be expected that man would evolve many theories by way of explanation, and he has. Each theory has in

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turn occupied a paramount position and in turn has been drastically modified or repudiated. It is, perhaps, wise to recognize an element of truth in all of the varied attempts to explain corrosion.

Qualitative Nature of Corrosion

It is somewhat difficult to be concise in any description of the causes of corrosive action. We may, for instance, make the assumption that a service is in contact with its environment under the normal conditions of temperature, moisture content, oxygen concentration, etc. Under such circumstances there exists a very definite driving force in a direction of the return of the metal to its most stable state. In simple language the metal exhibits solubility in its environment and solution is accomplished by the usual electrochemical means. There exists an electrochemical potential, the magnitude of which depends upon both the properties of the metal and the surrounding media. The magnitude of the potential is a measure of the tendency to corrode (dissolve), but not of the rate of corrosion, since that depends upon alteration of the contact zone by the products of initial action. Metal goes into solution in the form of metallic ions which carry electrical charges. In a balanced electrical system, the metal ions must acquire these charges by a loss of charge in some other part of the system. Consequently, if ions of other elements, whose stability in the un-ionized state is greater than that of iron, are present, such elements will give up their charge to the iron, allowing it to pass into solution; and the element will in turn be plated out. In most circumstances, the element is hydrogen which comes from surrounding moisture. The hydrogen is plated out at the contact zone replacing the iron. Such initial action eventually blankets the metal with a protective coating of the hydrogen film which would be effective in inhibiting further action if such a film were in itself stable. Unfortunately, it is not.

The protective hydrogen film will combine with dissolved oxygen to produce water or will pass off as a gas, the latter process being accelerated in acid solutions and retarded in alkaline solutions in proportion to the active concentration. Initial corrosion is, then, a two-stage process the rate of which may be limited by either stage.

Meanwhile, the iron which has passed into solution eventually reacts chemically with hydroxyl ions to precipitate as a hydroxide of iron and form rust. If such a formation is maintained in the contact zone, the rust coating affords protection. If it is removed, the de-

crease in concentration of iron ions from the solution favors the solution of more iron and the corrosion is accelerated.

Without further discussion and based only upon the brief considerations so far presented, some very fundamental observations can be made:

1. The metal must be in direct contact with its environment.
2. Moisture is necessary to corrosive action.
3. Oxygen is necessary for normal corrosion processes.
4. Corrosion is essentially an electrochemical action.
5. An electrochemical process infers oxidation and reduction to the extent that some element must be plated out of solution. Normally this is hydrogen.
6. Eventually the products of corrosion play an important part in establishing the rate of corrosion.
7. The action may be represented by a series of chemical equations, such as:

$\underset{\text{metal}}{Fe} + \underset{\text{ions}}{2H^+} \rightleftarrows \underset{\text{ions}}{Fe^{++}} + \underset{\text{atomic}}{2H}$	Initial stage of corrosion
$\underset{\text{atomic}}{2H} + \tfrac{1}{2}O_2 \rightleftarrows \underset{\text{liquid}}{H_2O}$	Destruction of H film
$\underset{\text{atomic}}{2H} \rightleftarrows \underset{\text{gas}}{H_2}$	Destruction of H film
$\underset{\text{ions}}{2Fe^{++}} + \tfrac{1}{2}O_2 + H_2O \rightarrow \underset{\text{ions}}{2F^{+++}}\ \underset{\text{ions}}{2OH^-} \rightarrow \text{Rust}$	Removal of iron ions

Variables Influencing Corrosion Rate

By the assumption of validity of the electrochemical nature of corrosion, a base upon which all else rests is established. Further considerations must deal with the many variables which influence corrosion rate. These may be listed as oxygen concentration, hydrogen ion concentration or alkalinity or acidity of the media, differences in composition and structure of the metallic material, soluble salts, protective coatings, localized influences as contact potentials or galvanic effects, and electrolysis. A complete understanding of the effect of all of these variables requires rather extensive study and only brief sections of this writing can be devoted to a sketchy résumé. Such sections occupy the latter part of this presentation and are written for the express purpose of establishing a picture which will

define the various terms commonly encountered in corrosion literature.

Protective Coatings

A protective coating is a coherent, impervious film of an insoluble compound which insulates the metallic surface from its environment. Difficulties are encountered due to porosity, solubility and chemical nature of the coating. A porous film may in instances actually accelerate corrosion by catalytic removal of hydrogen or by formation of an electrical couple with the metal.

Metal Potential

The metal potential is the solution tension of the metal which is generally expressed as a relative electromotive force and is a measure of tendency to corrode if all other variables are eliminated. The relative measurement is usually made against a normal hydrogen electrode at 1 mol per liter H ion concentration and a partial pressure of H_2 of 1 atmosphere. An example of such potentials is as follows:

METAL	ION	POTENTIAL
		volts
Calcium	Ca^{++}	−2.70
Aluminum	Al^{+++}	−1.28
Zinc	Zn^{++}	−0.76
Iron	Fe^{++}	−0.43
Lead	Pb^{++}	−0.12
Tin	Sn^{++}	−0.01
Hydrogen	H^{+}	0.0
Copper	Cu^{++}	+0.34
Gold	Au^{+++}	+1.30

Hydrogen Ion Concentration

Presumably, hydrogen ion concentrations may vary from 10 molal on the acid side to 10^{-15} on the alkaline side. Under usual conditions, however, the range of values experienced is quite narrow. Theoretically, it is possible to stop corrosion by a sufficiently alkaline solution, but in most conditions occurring in practice, the range of hydrogen ion concentration is not sufficient to affect sensibly the tendency toward solution as caused by the metal potential. Variation in hydrogen concentration does, however, exert a marked influence upon

the solubility of the products of corrosion and greatly reduces such protective effects, especially on the acid side. In broad aspects, the effect of pH may be summarized as below with the associated variables ranged in order of importance:

Distinctly Alkaline (pH 10 or greater)	*Neutral Zone (pH 4.3 to 10)*	*Distinctly Acid (pH 4.3 or less)*
Corrosion slow	Corrosion medium	Corrosion rapid
1. Protective films	1. O_2 concentration	1. pH
2. O_2 concentration	2. Protective films	2. H_2 overvoltage
3. Metal composition	3. pH	3. Metal composition
4. pH	4. Metal composition	4. O_2 concentration
5. H_2 overvoltage	5. H_2 overvoltage	5. Metal ion concentration
6. Metal ion concentration	6. Metal ion concentration	6. Protective films

It should be pointed out that in the so-called neutral zone, persons are prone to attribute more importance to pH than is justified by known facts. The truth is that total acidity is probably more important than pH value For example, tests show that equal amounts of carbonic acid and hydrochloric acid produce about the same corrosion, but that the pH of carbonic acid is only 5.5 as against 4.3 for hydrochloric. The same fact is undoubtedly true of the other weakly dissociated acids, especially the organic acids. Furthermore, in the neutral zone, it will be noted that oxygen concentration is considered to be a dominant variable, hence conditions of agitation or circulation are conducive to rapid corrosion.

Metal Ion Concentration

Metal ion concentration adjacent to the metallic surface could theoretically produce marked variation in solution rate, but, as with pH value, the range of concentration is limited due to precipitation reactions to form hydroxides of the metal. While some change in corrosion rate is undoubtedly due to the metallic ions, the variable occupies a position of minor importance as indicated in the previous table.

Overvoltage

No appreciable corrosion of metal will take place without current flow between points of different potential. Obviously, then, as metal enters a solution as an ion, one electrical equivalent of material must

leave. This material is hydrogen. As the hydrogen loses its charge to the metal it is plated out, presumably as atomic hydrogen. The accumulated film of plated hydrogen acts as a resistance to the passage of current. A certain energy is required to set free the atomic hydrogen in molecular form and the potential which is a measure of this energy requirement is termed the overvoltage. Without this overvoltage, iron in pure water would continually evolve hydrogen gas and corrode at a rate generally referred to as an initial corrosion rate and one which is extremely high. Strangely enough, the overvoltage is a function of the type and condition of the metallic surface and only to a minor extent dependent upon other factors. The higher the overvoltage, the more difficult it becomes to evolve free hydrogen from the surface. Relative overvoltage values as determined in normal sulfuric acid solution are presented below:

METAL	CATHODIC OVERVOLTAGE	METAL	CATHODIC OVERVOLTAGE
Zinc	0.75	Iron	0.27
Tin	0.49	Nickel	0.24
Lead	0.42	Aluminum	0.19
Copper	0.33	Platinum	0.17

Depolarization

Under practical circumstances the aforementioned liberation of gaseous hydrogen is not as important a factor as are the depolarization effects. The plated film of atomic hydrogen is said to polarize the circuit (diminish current flow), hence, any material which removes the film is said to depolarize. Since hydrogen is an oxidizable substance, any oxidizing agent such as dissolved oxygen, ferric iron, etc., in the contact zone, eliminates the protective hydrogen film, and corrosion proceeds. Furthermore, the usual oxide products of corrosion act as oxidation catalysts to speed the reaction. Zinc and the compounds of zinc are not oxidation catalysts; also, since zinc has a high overvoltage, galvanized materials are in common use.

Oxygen Concentration

The important rôle which oxygen plays in the corrosion processes is more or less evident from the understanding of the depolarization phenomena and the formation of oxidized corrosion products. In the initial stages of corrosion, the iron oxide (mill scale) may in a measure

serve as a protective film; the influence is, however, of brief duration. During corrosion additional oxides of iron are formed and tend to spread on the metal surface and out into the environment. This rust shields the metal surface from oxygen which tends to make the areas of rust development more anodic. On the other hand, depolarization consumes the available oxygen in the contact zone and further depolarization is impossible without diffusion of oxygen across the denuded boundary. Consequently, the rate of diffusion of oxygen across the contact zone in many instances limits the corrosion rate. Furthermore, the formation of the rust removes iron ions from solution (precipitation) and to some extent increases the solution potential thereby. In any event, oxygen plays an important rôle in the mechanism of corrosion and is perhaps the most important variable from a rate standpoint.

It appears obvious that any agitation at the contact zone will not only remove protective products, but will facilitate the transport of oxygen to the surface. Under conditions of agitation (variable water table, soil aeration, etc.) corrosion should be accelerated and experimental evidence bears out the contention.

Condition and Composition of Metal

Limitations of space prevent any adequate discussion of the influence of metal structure, physical conditions, or composition. Suffice it to say that all metal surfaces present sufficient irregularities of composition, stress differences, etc., to classify them as distinctly non-homogenous. As a result, certain areas exist at a different solution potential than others. Corrosion begins at the more anodic areas rather than uniformly over the surface, and pitting results. Discontinuity of surface films (mill scale), the presence of more than one solid phase, a solid solution of variable composition and structural deformations all constitute sufficient differences to alter potential and thus influence both the rate of corrosion and the distribution over the surface.

Dissimilar Contacts

When iron or steel is in electrical contact with another metal, salts of iron or salts of another metal, and both in turn are connected in a complete circuit through a conducting environment, the flow of current transports metallic ions and causes a variable degree of corrosion depending upon all factors which comprise the circuit. In short, a

battery is established and the action has been referred to as "galvanic action." One of the metals must corrode so that electrical energy will be derived from "chemical energy." Which one of the dissimilar metals will pass into solution depends upon the relative position of the two in the electrochemical series. The procedure is the same as

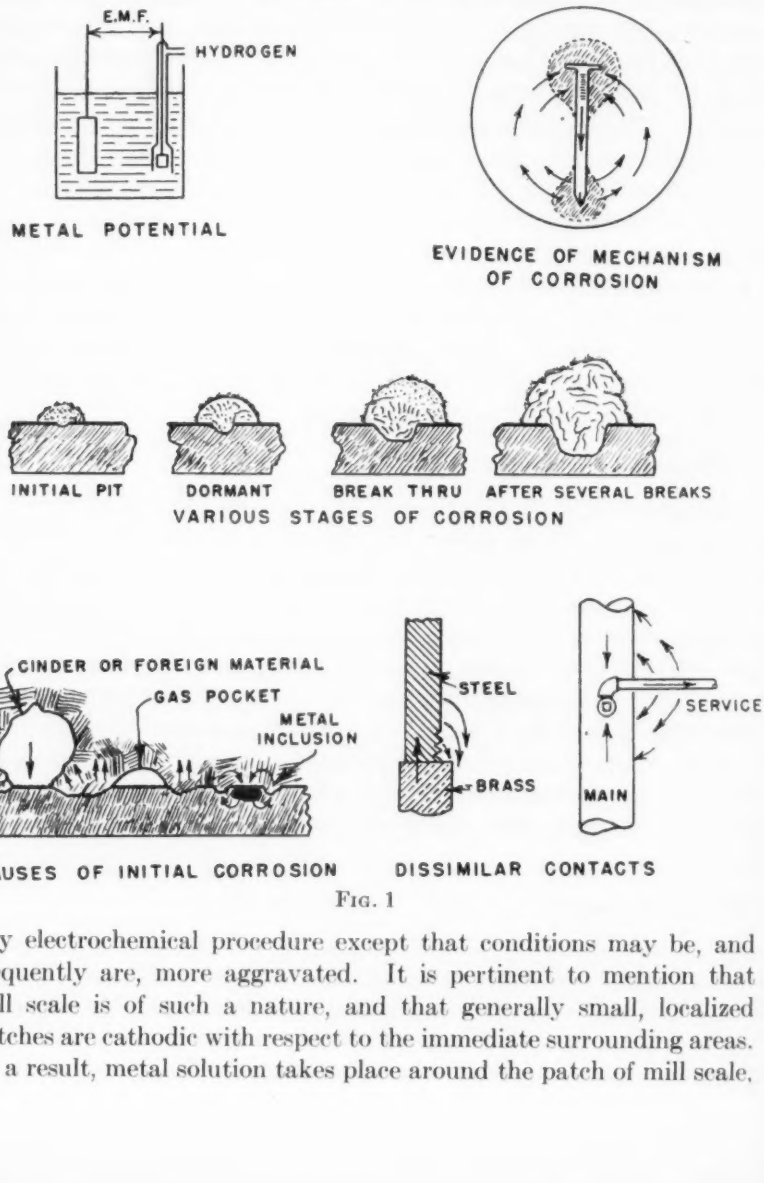


FIG. 1

any electrochemical procedure except that conditions may be, and frequently are, more aggravated. It is pertinent to mention that mill scale is of such a nature, and that generally small, localized patches are cathodic with respect to the immediate surrounding areas. As a result, metal solution takes place around the patch of mill scale.

numerous pits resulting. Usually, the deepest pits are associated with the thickest scale.

In connection with dissimilar contacts, too little attention has been paid to the contact of a single metal surface by solutions of dissimilar concentration. To form a "galvanic cell," it is quite possible to use two solutions of variable concentration of electrolyte and a single metal as well as the usual type consisting of a single solution and two metals. Where soil structure changes in type or composition, or where electrolyte concentration establishes gradients, "galvanic circuits" are possible, and one portion of a conducting metal becomes anodic with respect to another, consequently passing into solution.

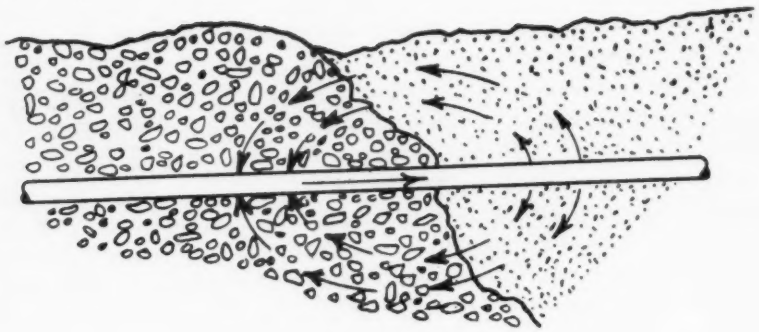
Other Considerations

Although the foregoing brief discussion mentions the more important considerations, the list is by no means complete. The specific nature and amount of other ions in the contact zone, cyclic stresses or periodic movements, soil composition and structure, biological action and the presence of oxygen carriers are all important in various instances.

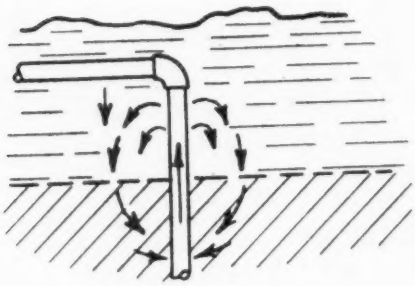
Corrosion Rate

It has been said, and there is much truth in the statement, that the most difficult thing to explain is why services last as long as they do. The assumption of theoretical circumstances permits the derivation of exact differential equations which define the time rate of loss of weight of corroding metal. Conditions of practical use accompanied by the eight to ten operating variables, all unknown in magnitude, make any practical study of corrosion rate a difficult matter. Of necessity, the experimental procedure has been one of observation and correlation of measured corrosion with the measurable contributing factors.

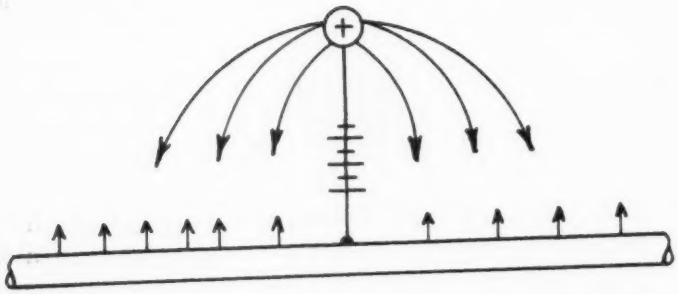
The writer digresses for a moment to remark that he has upon many occasions received pieces of pipe from different communities with an inquiry as to why it was pitted and corroded. The submission of such samples is futile. It is not possible to perform an autopsy and determine anything about the situation. Even an inspection of the location serves little purpose unless it can be extended over a reasonable period of time and accompanied by measurements pertinent to conditions. It is, then, inferred that a study of the causes and extent



DISSIMILAR SOILS



SOLUTION CONCENTRATION GRADIENT



CATHODIC PROTECTION CIRCUIT

FIG. 2

of corrosion is a long-time project and is logically connected with and tied to the replacement or maintenance of services. Only from extended and extensive observation can any fundamental information be accumulated. It is unfortunate that no general rules can be laid down to establish a corrosion study. The literature is replete with suggestions, but like all multi-variable systems, each circumstance is different and the systematization of a corrosion investigation program is a study in itself.

Electrolysis

To this point, all of the variables mentioned at the outset, with the exception of electrolysis, have been treated briefly. Fom the foregoing, it is evident that all corrosion might be termed electrolysis. The term is, however, more or less restricted to the effects of stray currents, more especially direct currents, which utilize services as conductors. Such electrolysis is, then, an external influence which is superimposed upon the picture of normal corrosive action. If services are used as conductors of electric current, either intentionally or not, current must enter and leave the service. If the situation is such that leakage of current occurs over an area of the metal, such areas are anodic and metal dissolves in proportion to the magnitude of the current flow. Furthermore, the current leaves the metal at the more naturally anodic areas so that the entire situation as regards stray current is one to produce accelerated corrosion. Fortunately, direct current systems are rapidly being eliminated or, at least, suitably constructed, so that stray currents are minimized and corrosion reduced.

The mention of electrolytic corrosion by stray current calls to mind the possibility of reversing the polarity so that current from an external source is provided to buck or neutralize that tending to leave the pipe surface at the anodic areas. If the arrangement is correct and the proper potential applied, corrosion at anodic areas can in this way be definitely limited or stopped. Such systems are termed "cathodic protection" circuits.

As regards alternating current, corrosion by stray currents is at the present time an open question. Factors of reaction rate time shorter than $\frac{1}{120}$ second as well as rectification to the direct current and the influence of the type of electrolyte in the ground water are involved. It is understood that a research program is under way as regards all of the factors concerned with grounding practices which superimposes an alternating current upon water services.

Summary

In this writing, the generally accepted mechanism of corrosion has been reviewed and the variables associated therewith described in a very brief form. It is impossible to obtain specific knowledge of the subject without rather concentrated study and it is hoped that the material in this paper may serve its purpose by contributing something to the understanding which can be gained from further study.

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Gastro-Enteritis Epidemic in a Large Office Group

By J. C. Geiger, A. B. Crowley and C. G. Hyde

THE Metropolitan Life Insurance Company occupies a large office building in San Francisco. At the time of the epidemic herein described its staff numbered about 954 persons. Of this number 314, or 33 per cent, were males and 640, or 67 per cent, were females. The office is operated on the basis of five working days per week.

On Monday, November 27, 1939, an outbreak of gastro-enteritis occurred in this group. It immediately attained epidemic proportions and continued its course through the working week, virtually terminating on Friday, December 1, as suddenly as it began. The peak was reached on Wednesday, November 29. During this period of five days 616 persons contracted the disease. This number represented nearly 65 per cent of the total group employed. During the succeeding week, from December 2–4, eight cases were reported. By December 4 the normal incidence of dispensary cases of illness was resumed. Preceding the outbreak, during the period November 9–26, in 12 working days, 23 cases of illness were reported, practically two per day. Including all cases between the dates of November 9 and December 4, the total number afflicted was 647, or 68 per cent of the entire staff. The incidence among males and females was 64 per cent and 70 per cent, respectively.

Of this whole group, 299, or 46 per cent, had fever; 511, or 79 per cent, had nausea; 434, or 67 per cent, had pain; 551, or 85 per cent, were afflicted with vomiting; and 490, or 76 per cent, had diarrhea.

An interesting study was made of the date and hour of onset by two-hour periods during the period of five days, Monday, November 27, to Friday, December 1. As stated above, 616 cases were incurred

A contribution by J. C. Geiger, Director of Public Health, City and County of San Francisco, A. B. Crowley, Chief, Industrial Division, Department of Public Health, San Francisco, and C. G. Hyde, Consultant to the Director, Department of Public Health, San Francisco.

in this interval. This number constituted 95 per cent of the total of 647 cases occurring during the epidemic. Of particular interest are the three days, Tuesday, Wednesday and Thursday, when 560 cases occurred. These constituted 91 per cent of the week's total and nearly 87 per cent of that for the entire epidemic.

On Tuesday, November 28, the onset period lasted for perhaps 22 hr., beginning about 2 P.M. of that day and extending to approximately noon of the day following. The peak was reached between 8 and 10 P.M. Tuesday evening when 32 persons, or 16 per hr., were stricken.

On Wednesday, November 29, cases began to appear at about 2 P.M. and continued until about noon of the following day, again through an onset period of 22 hr. The peak occurred from 8 to P.M. on Wednesday, when 74 cases were reported as having their onset. A high incidence, involving from 16 to 37 cases per hr. prevailed from 6 P.M. on Wednesday to 4 A.M. on Thursday, an interval of 10 hr.

On Thursday the incidence was much lower. The onset began, as before, at about 2 P.M. and lasted until about 8 A.M. on Friday, an elapsed onset period of 18 hr. The peak was reached at about 8 P.M. and lasted for 6 hr. with from 11 to 12 cases during each 2-hour period.

The numbers of cases having their onset during each of the five days in question were as follows: Monday, 12; Tuesday, 121; Wednesday, 262; Thursday, 177; Friday, 44; total, 616.

Environmental Conditions

Every conceivable effort is made by the company to maintain the most salubrious and healthful conditions possible among its staff of employees. A sick clinic and dispensary are available to all workers without cost. Free luncheons are served to the entire group in an airy, well-lighted cafeteria provided with every modern convenience. Adequate and convenient rest rooms with toilets, and lavatories, supplied with both hot and cold water, are provided throughout the building. For the most part the plumbing system is modern and sanitary. The investigation revealed a small number of water closets in which back-siphonage could occur. These were promptly provided with siphon breakers. Drinking fountains supplied with cold water are provided at convenient locations throughout the building. An excellently equipped clinical laboratory is available to the employees.

The staff includes an experienced, able medical officer and a public health expert of national reputation.

The cafeteria accommodations are such that, with the exception of the officers and department heads who eat in separate dining rooms, it has been necessary to divide the staff into seven groups, each of which has a 15-minute luncheon period. These seven periods begin at 11:25 A.M. and end at 1:10 P.M. The number of persons per luncheon group averages about 116, ranging between 100 and 120.

The water supply of the building is obtained from city mains. It is thoroughly chlorinated but not filtered. The supply is derived from the Sierra (Hetch Hetchy) system, from the ground and a large reservoir (Calaveras) on the east side of San Francisco Bay, and from three reservoirs on the San Francisco peninsula. The pressure zone in which the building is located is supplied by Laguna Honda, an uncovered distributing reservoir in a densely populated portion of the city. It is flanked by a main thoroughfare.

The building has two sections, known as the old and new wings. The water supply systems are for the most part separated. Each has a cooling plant for drinking water. Certain features of the cooling system in the old wing, as they existed at the time of the epidemic, were such that the system might properly be regarded as less satisfactory, and perhaps less sanitary, than that in the new wing.

Moreover, as indicated above, certain toilets in the dressing rooms of the old wing were unsatisfactory because their flush valves might possibly have permitted of back-siphonage. Many of the female employees habitually drank water from the faucets of the lavatories in these rooms.

Statistical Survey

Through the company's expert services, and because of the homogeneity and compactness of the group, it was possible to conduct a statistical study of the outbreak so complete and trustworthy that it may perhaps be considered unique in the history of epidemiology.

This notable survey involved some 26 statistical studies covering the epidemic in every phase which was susceptible to such form or type of inquiry. The studies naturally dealt, primarily, with the character and incidence of the disease itself. This phase of the investigation comprehended ten statistical analyses. The possible vectors of food and water were subjected to a survey which included ten additional statistical studies. The remaining statistical in-

vestigations, six in number, were concerned with the locale of the work of the office personnel and the possible influence of propinquity or contact in the dissemination of the disease.

Discussion of Statistical Findings

The actual outbreak began on Monday, November 27, with 12 cases reported. On the three following days the incidence was, respectively, 121, 262 and 177, a total of 560 cases, or 87 per cent of the entire group of 647 persons afflicted. On Friday, December 1, 44 cases occurred. The statistics with respect to symptoms, numbers of cases preceding and following the main outbreak, and relative incidence among males and females have been given previously.

The average number of absentees during the period November 6–24, 13 working days, was 34. A study made to determine the relative incidence of the disease among those thus absent, as compared with those who were at work throughout this period, indicated that there was no effect and that 68 per cent of this group were ultimately afflicted.

Of the total group taken ill, 82 per cent reported to the dispensary for treatment. As to sex, 74 per cent of the male and 85 per cent of the female cases so reported.

Of the 647 ill, 95, or 14.7 per cent, reported cases in their families. The number of such family cases was 138, or an average of 1.45 per employee. Of the 307 not ill, only 18, or 5.9 per cent, reported cases in their families. The number of such cases was 40, or an average of 2.2 per employee.

In the families of employees who were ill with the disease there were 95 cases, or 69 per cent of the total family cases, which occurred at such a time that they might conceivably be considered to have been secondary to the employee cases.

In the families of employees who were not ill, 62 per cent of the cases occurred prior to November 27, and 30 per cent after December 1, leaving only 8 per cent, or 3 cases, occurring during the main outbreak among the company staff.

Of the 95 cases occurring in the families of employees who were ill and which might have been secondary cases, 16, or 17 per cent, had their onset within 24 hr.; 34, or 36 per cent, came down with the disease within 48 hr.; 53, or 56 per cent, were taken ill within 72 hr.; and the remaining 42, or 44 per cent, after 72 hr.

An inquiry into the incidence of the disease among the seven luncheon groups eating in the cafeteria revealed the fact that the total number and the percentage of those taken ill increased steadily to a peak during the middle period, 12:10 to 12:25 P.M., after which the values subsided to points lower than at the beginning. The beginning, peak and final percentages were 69, 83 and 62. It is difficult to find any ground of explanation of this circumstance. In this connection it is of interest to note that only 42 per cent of the culinary workers, 24 in number, were afflicted and only 45 per cent of the officers and department heads, totaling 69 in number.

A survey of articles of food eaten in the cafeteria on Monday, November 27, and Tuesday, November 28, the first two days of the main onset, by representative groups subsequently taken ill, showed that no single food and no group of foods could have been responsible for the outbreak. This fact is of particular significance because epidemics of this nature are commonly attributable to contaminated foods. The sample group of November 27 contained 208 persons; that of November 28, 62 persons.

Similarly, infected water supplies have been determined to be a main cause of such outbreaks as that under consideration. For that reason every phase of the water supply problem was investigated with great care and in immense detail, both statistically and from physical and bacteriological standpoints.

All cases were examined with respect to their habitual and occasional places of obtaining their drinking water. The investigation of habitual drinking places revealed the fact that the incidence as among those using the water supply of the old wing, versus that of the new wing, was virtually the same, namely 68 per cent among the former and 66 per cent among the latter. Similarly, the incidence among those whose usual drinking places were the fountains in either the old or the new wing was closely the same, being 67 and 65 per cent, respectively. The incidence among women habitually obtaining their drinking water supply from dressing room lavatory taps was 73 per cent for the old wing and 61 per cent in the new wing. The former group, however, was nearly twice as large as the latter. While it is true that the toilets in the old wing dressing rooms might possibly have been subject to back-siphonage under very extraordinary conditions, the relatively small incidence difference between these two general locations must eliminate back-siphonage as a major

factor, or any factor, in the epidemic. It is obvious that as between the two nearly separate systems of water supply in the building, i.e., in the old and new wings, there was no qualitative difference. It is further obvious that water alone could not have been the cause of the epidemic and probably could not have been involved at all. Moreover, it may here be stated that a careful survey of the entire neighborhood, including several large apartment houses, failed to reveal any significant number of cases of sickness of the type under consideration. Furthermore, there was no evidence that the disease was current elsewhere in the city.

The fact that the cooled water supply of the old wing of the building could not have been specifically involved was attested by a comprehensive study of the number and per cent of persons ill who drank regularly, occasionally or never from any source connected with the cooling system of that wing. It was determined that the incidence among those who never drank water from this system was only 5 per cent lower than among those who habitually used this drinking water supply.

The role of propinquity, or contact, in gastro-enteritis outbreaks is not as definite or determinable as are other causes such as food and water. In the present case the circumstances were studied in great detail in the hope that, if contact were a factor, its influence would be revealed both qualitatively and quantitatively.

Approximately 37 per cent of the total group were definitely allocated in their work to the old wing of the building and most of the remainder, or 60 per cent, to the new wing. Among these groups the incidence of the disease was 64 per cent and 71 per cent, respectively. Some 28 persons worked in both wings. Of these, 15, or 54 per cent, were ill. Male workers were evenly divided between the two wings, but there were twice as many women employed in the new wing as in the old.

Of the 69 sections into which the employee group may be divided there were 32 in which the number of workers was 10 or more. The average population of these larger groups was 24. The average number of employees in the remaining 37 sections was 5. The maximum number in any section was 52. The incidence of the disease was found to be 68 per cent in all cases, namely in all 69 sections taken together, in the 32 larger sections and in the 37 smaller sections. The highest incidence in any group of 10 or more was 94 per cent.

The number of persons in this particular section was 17. The second highest incidence was 82 per cent in a section involving 28 persons.

A study of the case records disclosed the fact that on Tuesday, November 28, a disproportionate number of employees were taken ill in certain sections as compared with other portions of the building. The sections thus involved were 5 in number on the sixth floor. The total number of employees therein was 93. On the date in question the incidence was 31 per cent as compared with an average of 11 per cent elsewhere in the building. Moreover, the incidence for the entire epidemic was 75 per cent for this group of sections, or 7 per cent higher than the general incidence. No explanation has been deduced to account for this circumstance.

Health Department Investigation

At the request of the company the San Francisco Department of Public Health conducted an investigation which included the following principal features:

1. A survey of the plumbing system of the building to discover possible cross-connections and the chance of back-siphonage from defective toilets.

2. A series of bacteriological samples and laboratory analyses of the public water supply in the neighborhood of the building and of the various sources of supply within the building itself; also of the food served in the cafeteria.

3. A series of stool samples and laboratory analyses to determine, if possible, the organism or organisms responsible for the outbreak.

4. An inquiry to discover whether or not similar cases of illness prevailed in the apartment houses and offices in the neighborhood of the company building.

5. A review of the statistical data obtained by the company staff, and advice concerning possible valuable lines of further study and investigation.

The plumbing system of the old wing was naturally less modern and excellent than that in the new wing. A few cross-connections were discovered in both wings and were promptly eliminated. In spite of these potentialities it did not appear that these were in any way involved or that either the public water supply furnished to the building or the supply within the building itself was responsible for the epidemic.

The bacteriological analyses of samples of melted ice (1) and of water (8) collected from various places within the building during the progress of the epidemic were all negative for *Esch. coli* in all 10-ml. portions examined. These samples were collected on Wednesday and Thursday, November 29 and 30.

Samples of food collected on the same days were tested and found to be negative for any type of food-poisoning organism. These samples included fruit compote, chili beans, beef and kidney stew, assorted cold meats, cheese, hard boiled eggs, beet pickle and egg salad, salad oil, mayonnaise, custard, frankfurters, and string beans.

On December 14, six samples of the public water supply at various points in the vicinity of the company building were taken. The counts at 37°C. were 1 per ml. in 5 of the samples and 5 per ml. in the remaining sample. *Esch. coli* were absent in all 10-ml. portions examined.

On December 16, 19 and 20, 31 additional samples of water were collected from as many different places in the building, including a warm water storage tank and various representative taps and fountains. All were negative for *Esch. coli* in 10-ml. portions. The total counts at 30°C. ranged from 1 to 5,000 per ml.

Stool samples, 35 in number, were collected and examined in the department laboratory. All were negative for types of organisms which might have been the cause of the epidemic.

Inquiry failed to reveal any significant number of cases of gastro-enteritis in the neighborhood of the company building or elsewhere in the city.

Conclusion

Despite the elaborate investigations—physical, bacteriological and statistical—which were conducted to determine the cause of this outbreak, none was discovered. Its source remains an epidemiologic enigma which bids fair never to be solved satisfactorily. As in most sudden onsets of this sort the bacteriological samplings were probably undertaken too late to be of determinative value. Moreover, the extent of current basic knowledge and the techniques now available may not be adequate. In this instance there was no proper mass of circumstantial evidence by which the guilty agent could be detected.

ABSTRACTS OF WATER WORKS LITERATURE

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DEFENSE

Domestic Materials in the Water Supply Industry. HELLMUT GÖTTING. Gas u. Wasserfach. (Ger.) **84:** 121 (Feb. 22, '41). *Excerpts.*

[EDITOR'S NOTE: This free translation is published so that JOURNAL readers may learn of the various substitute materials found serviceable in present-day German water works practice. In certain instances the author refers to limitations of certain coating materials which do not exist in American practice.]

"Within the boundaries of the 'Reich,' materials, which are at least as good as those that must be imported, are now available. We are, therefore, striving to produce, with domestic materials, useful articles which are the equal of those previously produced with alien materials. Economies must be effected primarily in the use of tin, lead, copper and alloys of iron. Since iron cannot be replaced in certain of its applications, and since it is indispensible in certain uses, other material must, as far as possible, replace it and projects must be completed with the least use of iron. Government authorities have, in their regulations, indicated the paths to be followed. In addition, every member of the profession is urged to economize voluntarily in all materials necessary to carry on the war and to exercise care in the use of indispensable alien materials, at the same time urging his co-workers to do the same.

"Domestic materials have proved better than alien ones in many uses, so that their substitution has proved to be a technical advance. Especially in the water supply industry must stress be laid on the lasting qualities of the material employed, even under the most unsatisfactory operating conditions. The surety of operation must be given prime consideration. The supply of drinking and fire-quenching water must never be interrupted, even in an emergency. Therefore, the materials employed must be highly resistant to strain and corrosion. One should not be surprised that certain materials which have proved satisfactory in machinery construction must be rejected for use in water supply systems. If a material is not corrosion proof or cannot be made so by suitable surface protection it is useless for water supply. The materials employed must not contaminate the water nor must they be attacked by the water or the surrounding earth.

"The following examples will serve to demonstrate how, under these conditions, available domestic materials have proved their value in water preparation, distribution and delivery and so far as can be predicted, will continue to do so.

Ground Water Supply

"Substitute materials have been used primarily as well linings in the water supply field.

"Before the institution of the Four-Year plan, experiments had been made in the use of non-metallic materials, as the life of driven well with strainers of copper or iron covered with fine mesh metallic cloth had not proved satisfactory. These metals possessed great resistance to tension, flexure and shear, and were therefore capable of resisting the stresses caused by ground slippage and settlement. After a time, due to incrustation, however, the production decreased so much that the wells had to be taken out of service. The substitution of non-metallic materials is, therefore, of considerable importance in this respect, especially as the life of the well may thereby be increased considerably. Copper is no longer necessary for wells and its use in them is therefore prohibited, the non-metallic screens being made of porcelain, wood, or earthenware.

"Porcelain screens have already been installed and tested in a considerable number of wells. One company has delivered screens for 600 wells. Porcelain screens must naturally be protected against impact and flexure. To achieve satisfactory results, the driving of the well and the installation of the gravel should be entrusted only to contractors of wide experience. The Jaeckel screens are still installed for certain purposes with the help of wrought-iron bells that are cemented on the sleeve or pipe end, with elastic packing inserted between them. The Jaeckel screen and the Schonebecker screen are also furnished with sleeves which must be filled with an elastic material. This connection is the same as that used in the earthenware screens.

"Wooden rod strainers were already in use shortly after the World War. In the Wissman wooden rod strainer, the individual oaken rods are fitted to a slit pipe and held together by metal bands. The Schonebecker wooden strainer gives another solution. The thick walled staves of stone oak, impregnated birch or fir have slots, which are widened toward the center, cut into them. The individual strainers and pipe end are provided with course teeth which engage each other. These teeth are treated with 'dope' and then covered with an elastic sleeve. A flexible coupling which keeps out sand and surface water is thus provided. Care must be taken when wood is used as water causes it to swell. The slots are therefore to be made of such a size that after swelling takes place they are still large enough to allow the water to pass and still hold back the gravel.

"A whole series of earthenware strainers has been developed, but only a few will be described here to show the essential features of the type. The Hähnchen screen is constructed as a bell filter for sand, gravel and broken stone with a single or multiple layer of gravel. The individual bells are superimposed in a manner similar to Venetian blinds, thus forming ring-shaped free spaces. Inverted, the strainer is similar to the gravel pocket filter used in fine sand. In the shot-jacket screen the inner packing of gravel has been copied in order to avoid the gravel packing. The Schönebecker ribbed screen has also been designed for gravel packing. The longitudinal ribs which also serve to reject the gravel give the screen additional strength; and the earthenware screen and riser pipes are joined together to form the well. The ends of the pipes are ground to a plane fit. In the bottoms of the bells, elastic rings are inserted so that the earthen pipe does not come into contact. The ring space in the bells is packed with oakum and the bell poured with bitumen. Special care should be taken with the joints in the upper part of the well so that no contaminated or insufficiently filtered water can leak into the well through a faulty joint. Under no condition should moisture be tolerated in a joint that is to be packed. The spigot ends and the bells are thoroughly primed when dry so that a close bond may be had between the glazed surface of the pipe and the packing bitumen.

"If care is taken in the use of domestic materials in the construction of a well, results at least equal to those with metal may be obtained. It should be mentioned briefly that experiments have been made with glass and cement. When glass rings were used, metal fasteners still had to be used, and when

cement was used the screening cross-sections had to be smaller than in the case of the materials previously described. Still to be mentioned are Remarit, a chrome-manganese steel, and the well-known V2A steel, as well as steel provided with a glaze and the Lafiro screen of copper-plated steel. Since these materials are in demand for more important purposes, porcelain, wood and earthenware are to be preferred.

Treatment

"Filter plants constitute an additional field for the use of domestic materials. The previously customary filter supports were, in many cases, of metal which was vigorously attacked by the strongly aerated water. The considerable rusting away of such a structure is only revealed in cleaning. Therefore filter supports have lately been constructed of materials which are not attacked by water. In Magdeberg, filter bottom plates were made of reinforced concrete into which threaded porcelain capsules were cast, porcelain nozzles being screwed into the same. A filter bottom of asbestos-cement was constructed in Berlin. Porcelain is also suitable for this purpose. Asbestos-cement has the advantage of being easily worked and highly resistant to the action of water. It follows that the filter wash piping which is situated under the filter bottom and which is alternately in contact with air and strongly aerated water should be made of non-metallic materials. Cement blocks and asbestos-cement plates are used to support piping. Piping and distributing boxes are made of asbestos-cement in which are inserted nozzles of porcelain. Plastic pipes made of Polyvinylchloride, known by the names, Vinidur, PGU, and Igelit and Mischpolymensate, made of carbon and lime are also used for wash piping; but these pipes should be used by experts, who have the special knowledge necessary for their use. In the case of domestic material the success in their use is immediate if a suitable authority undertakes the proper selection and installation of the material. Various ordinances and instructions have emphasized the fact that, in the selection of various materials, those that require cast iron should be given preference. For buildings, reservoirs and elevated tanks, reinforced concrete, arched construction or even plain masonry are to be given preference in the future. Particulars of this situation cannot be given.

Distribution

"For transporting water from the water works to the consumer, piping of cast iron, centrifugally-cast iron and steel were primarily considered up to date. The wall thickness of these pipes was reduced to the DIN standards. This prevented the burial of unnecessarily large amounts of iron in the ground. The wall thicknesses were set at such a high figure by some that when the soil or water attacked the pipe there would still be a sufficient reserve of strength. This has been corrected. Extra importance, however, was thereby attached to pipe protection. This protection must be made so good that rusting and tuberculation are positively prevented. All steel pipes are therefore provided with an external coating, consisting of bitumen and bitumen-saturated wool felt.

"The bitumen protection has proved its worth. The previously employed petroleum bitumen was dependent upon the importation of petroleum from foreign countries. Extensive experiments were therefore made to produce bitumen from domestic materials and, also, to employ the coal-tar pitch recovered in the distillation of coal. Centrifugally-cast pipe has for some time been protected with a mixture of bitumen and coal-tar pitch. For the protection of the outer surface of steel pipe, coal-tar pitch is used in part while the inner surface is for the time being protected with bitumen. This prevents the water from being contaminated by the taste of coal tar pitch [see Editor's foreword]. To prevent tuberculation during operation, the inner coating should be made as dense as possible. In the steel pipe this is achieved by rolling in the 1 or 2 mm. thick layer of material. A cement-mortar lining may also be applied to

steel pipe by centrifugal force. This illustrates a transition from steel pipe to reinforced concrete pipe.

"For reinforced concrete piping which must stand an especially high internal pressure, a thin sheet iron pipe is coated inside and out with cement. The remaining centrifugally-cast cement pipes are reinforced with iron wire. The use of these pipes insures a notable saving in iron in comparison with cast-iron and steel pipe. The wire reinforcement may also be given an initial strain in order to increase the strength of the pipe. In this connection, mention should be made of the Freyssinet pre-stressed concrete pipe, manufactured by a German company, which will shortly be delivered in 800 to 1200 mm. [31.5″ to 47.24″] inside diameter.

The best method of joint making for cement piping is still a matter of controversy. It is advisable to make the connections elastic so that subsequent settlement will not cause breaks in the pipe. In experiments made with one sleeve, the cement ring, which was put in before hemp was tamped in, was separated by a ring of sheet metal from the sleeve so that the cement was connected only to the spigot end, leaving 1 to 2 mm. space between the cement and the sleeve. The sleeves on pipes of 300 mm. [11.81″] withstood an internal pressure of 12 atm. (180 lb. per sq.in.). In addition the pipe could be deflected several degrees without difficulty. Neither breaks nor leaky joints developed.

"Before ordering cement pipe it must be determined that neither the water nor the earth surrounding the pipe has any deleterious effect on it. Under certain conditions it may be necessary to apply a protective coating. The installation of valves, tees or elbows presents no difficulties. For this purpose welded transition pieces are employed. The packing consists of elastic rings which rest upon the cement pipe and are forced into the transition piece. For this purpose a pressure ring and a loose flange that is screwed upon the transition piece are used.

"While the centrifugally-cast cement pipes are used principally in systems of large diameters, asbestos-cement pipes are used for the smaller ones. Asbestos fibres must be imported to manufacture this pipe, but they are, in a certain degree, available. This pipe is suitable for suburbs and other districts in which the water consumption is small and where the danger of freezing in cast-iron pipe exists. In addition to the well-known roll-ring connection, another compression coupling similar to that designed for centrifugally-cast cement pipe was developed for asbestos-cement pipe. This coupling consists of a threaded center ring placed over the joint in the pipe. Elastic rings are placed on the pipe at each thread of the ring, and two screw flanges are screwed on the center ring to compress the elastic rings. The domestic materials which are to connect iron pipes can be mentioned only briefly. Bells can be calked with wood wool and rope, either in the natural state or saturated with bitumen in place of hemp. Cast lead or lead wool may be replaced by aluminum wool, Sinterit and Mundit. The various welding processes for steel pipe have been reported in detail, attention having been given to methods of coating the pipe internally.

Services and Meters

"The thicknesses of wrought-iron pipes used for house installations have been in part reduced by standards DIN 244 OU. The smaller-diameter pipes, which are used for distribution, are galvanized with zinc, and the larger sizes, 1½ in. and up, are coated with bitumen. For the service connections between the street main and the meter, plastic pipes have been used experimentally. This domestic product, called Polyvinylchloride, mentioned above, is not attacked by water, lye or most acids. Therefore, it finds much use in the chemical industry. Service connections of 20 Mipolam, which have been installed two winters, have lasted very well, although they lay part of last winter in the frost zone. The portion of these services in the street was protected from other works by a cable covering. Individual plastic pipes were connected with bells. The ends of the pipes are carefully heated and spread to the diameter desired for this purpose. The

bells and pipe ends are painted with a special cement and forced together. This cement guarantees a sufficiently adhesive joint. The connections at the tapping sleeve and the meter are made with iron connections and adhesive cement. The connections are heated with hot air when they are to be joined.

"One must be prepared to use other methods when using new materials. For example, it is advisable not to cut the same threads in plastic pipe as are used in gas piping. In house installation as in service connections these pipes should be entrusted only to skilled workmen who will protect them from blows. It should also be remembered that brittleness increases as the temperature drops. The plastic pipes are particularly suitable for use in cities in which the iron service pipes are rapidly corroded or tuberculated.

"Plastic pipes have proved unsuitable for hot water. For use in this important field the necessary material, with its cement, which will meet all conditions still remains undiscovered. Extensive experiments with porcelain and Kuprema pipes have been made. Porcelain pipes must be installed with care. They must not be exposed to flexure, but must be able to stand expansion and contraction. Porcelain and glass piping have therefore not found very extensive use in water supply. Kuprema pipe consists of a thin copper pipe of a few tenths of a millimeter thickness around which a jacket of hard paper is wrapped. The pipe is connected with compression couplings. Since a certain amount of copper is required to make Kuprema pipe it cannot be considered domestic material and therefore cannot at present be used.

"Meters, on the contrary, are constructed almost entirely of domestic materials without in any way affecting their accuracy or appearance. In the last years various parts, such as the wheel ring cylinder and gear wheel, were made of hard rubber or artificial resin. The parts that were made of nickel are now made of stainless steel or plastics. The cover, instead of brass, is now made of synthetic resin.

"The housings of water meters have of late been made of zinc in accordance with DIN 3260 U. Large quantities of zinc are now available so that the substitution for brass and other import materials is advantageous. The surface of the zinc, except for the machined surface of the flanges, is coated with a baked-on water-tight enamel which is applied at a temperature of 120°C. [248°F]. An alloy low in copper is used. Zinc has been so successfully refined that it is available in a purity of 99.99%. For casting and the production of rods, it has been alloyed with a few per cent of copper, aluminum and other materials. Four years ago the Berlin water works, in making extensive experiments, installed 1,000 sleeves made of zinc [zinkspritzeguss]. In order to facilitate the installation and removal of the meter they were located between the shut-off valve and the meter. The metal consisted of 91.9% zinc, 3% copper, 5% aluminum and .05% silicon. At the same time several sleeves were made of drawn zinc. The fittings were partly coated with acid-free fat which gave additional protection against corrosion. A large number of meter connections, of zinc or zinc-coated [temperguss], which consisted of a threaded nipple and shroud nut similar to that used on a union, have been installed in the last three years in accordance with DIN 3261 U. All these parts have since proved their worth. Doubts about the advisability of using it in cold water supply lines are contrary to experience in the World War, during which impure zinc without sufficient protection was used, since detailed instructions for the production and working have been issued by suitable authority. To prevent unpleasant surprises it is advisable not to save pennies at the wrong end in the use of zinc. Attention should be paid to see that the manufacturer uses pure zinc in his alloys, uses suitable machinery, and protects the surfaces perfectly. The individual parts must be phosphated or chromated. In the latter, the chemical treatment must be followed by an anodic one. Finally the surfaces must be coated with a suitable enamel or fat. This careful protection of the surfaces increases the life of the parts considerably and is just as useful as the present general practice of protecting iron and

steel. Of late, stems for small street valves have experimentally been made of zinc.

"For packing flanges, gaskets of synthetic resin, Klingerit and pasteboard have been used in place of rubber with good results. Domestic materials are finding increased use in house services. The use of ceramic materials for wash and closet basins has followed. Flush tanks of closets are lately being made of glass, plastics or earthenware. The float and the bell in the flush tank are now being made of glass or porcelain. For storage batteries, glass and porcelain have proved their value. Battery jars up to 90 liters [about 24 gal.] have been made of these materials.

"A field in which light metals can be successfully substituted is in fire protection water supply. Standpipes, couplings and transition pieces are being made of a corrosion-resistant alloy. As these parts are in contact with water only a short time no corrosion occurs. The upper part of manholes for hydrants, gate valves and tapping sleeves are still made of cast iron. The lower part consists of a cement box into which a plate with the movable cover is set. Such manholes, of similar construction as they may be made today, have been tested in practical operation for some time.

Summary

"These examples show to what extent domestic products can be used in the water supply industry. One thing must be clearly understood—that in the use of substitutes, everything depends upon the spirit in which the work is accomplished. Success or failure depends upon the willingness of the men who are doing the work. If here and there a failure occurs, every effort must be made to establish the cause, so that the mistakes will not be repeated."

Repairs to a Reinforced-Concrete Reservoir. JOHN FRANCIS HASELDINE. J. Inst. C. E. (Br.) **16:** 6: 205 (Apr. '41). *Excerpts.*

"The structure in question is a reinforced-concrete covered service reservoir containing, when full, 12′ of water. The walls are 12″ thick at the base and 8″ thick at the top, and at the point where the damage occurred 11″ of the structure is above the natural surface of the ground. The concrete structure is enclosed in an earth bank with a slope of 1 in 2, and the reinforced-concrete roof, which is 6″ thick, is covered with 1′6″ of earth and gravel.

"A bomb fractured the wall, buckling about two and a half bays of the roof and fracturing the concrete at the top and bottom of two reinforced-concrete columns, which were also forced out of the perpendicular. A portion of the floor under the damaged roof was punched down by the explosion and cracked.

"The reservoir attendant was on the site immediately after the damage, and measured the depth of water, which was found to be 10′3″. He continued to measure the depth from time to time, and found that the reservoir was not losing water; the earth bank, which was of a clayey nature, was evidently retaining it. No further water was put into the reservoir, which was allowed to empty by gravitation to the district of supply. No water was lost.

"At first sight the obvious method of repair appeared to be to cut all the reinforcement with shears, remove the debris, and reconstruct the damaged portion; but after further consideration it was decided to break the concrete from the steel, and this was done by small pneumatic chisels and hand hammers. When this had been done it was found that most of the steel was sound, although bent; and it was straightened out in place, only fractured bars being replaced with new, to the extent of approximately 10% of the total steel in the reinstatement work.

"As the straightened steel was not in such perfect lines as it had been in the original wall, it was thought advisable, in order to ensure ample cover of concrete over steel, to thicken the concrete by 3″ on each face, and this also allowed the new concrete to overlap the old concrete on both the inside and outside faces at the junction with the old work.

"The two damaged columns were forced into the upright position, and were encased in concrete 3″ thick with some light wire-reinforcement.

"The damaged floor was covered with a mat of concrete 3″ thick.

"One of the roof beams was rebuilt with new steel to the original dimensions, and in the other the steel was straightened and the concrete slightly thickened. The repairs were carried out, working a normal 48-hour week, by a foreman, a working ganger, and six men. Test has proved the work to be sound and water-tight.

"The damage occurred at the position of a 10-inch inlet pipe and the puddle-flanged ['wall-fin' in U. S. usage] pipe in the wall was fractured; to wait for a new puddle-flanged pipe to be cast might have caused unnecessary delay; therefore a 10-inch ordinary pipe was cut and jointed so that the face of the socket came in the wall in the position in which the puddle-flange had been situated, and the outer coating of the pipe was burnt off where it was built into the wall."

Detection and Determination of Arsenical War Gases in Drinking Water. E. SCHULEK AND P. RÓZSA. Pharm. Zentralh. (Ger.) **80:** 553 ('39). Arsenical gases in water may be detected by following method: 100–2,000 ml. of water shaken with 0.05 gram activated carbon, and mixture filtered. Carbon and filter paper digested with oleum and hydrogen peroxide, 0.2 gram of hydrazine sulfate added, and, after dilution, arsenic titrated (*p*-ethoxychrysoidine) with potassium bromide-potassium bromate. End-point confirmed by addition of α-naphthoflavone soln. followed by 1 drop of potassium bromate soln.; rust-brown color formed. Content of arsenic may also be confirmed by Gutzeit or Marsh test of titrated soln. Many examples, using arsenic chlor-diphenyl and fractional extraction by activated carbon, described.—*W. P. R.*

STREAM POLLUTION AND ITS CONTROL

Congress Tackles River Pollution Control. ANON. State Govt. **13:** 4:67 ('40). Since '36 proposed legislation for pollution control has constantly been before Senate and House of Representatives. The many bills on this subject have differed principally in that some have provided for Federal regulatory control while some have limited function of Federal Govt. to co-operation, leaving control of pollution in hands of States. Two schools of thought seem to have found a common meeting ground in legislation which is now pending before Congress. Bill introduced by Senator Barkley and passed by Senate during first session of Seventy-Sixth Congress recently received some revision in hands of House and is now in conference committee. On March 1, '40, House passed Senate bill with amendments which eliminate financial allocations to States and reduce authorized appropriation to Public Health Service for administration to $250,000 a year. In addition House added amendment which is perhaps most significant of all. This amendment declares that after date of enactment of law "no new sources of pollution, either by sewage or industrial waste, shall be permitted to be discharged into navigable waters of U. S. and streams tributary thereto until and unless approved by the Division." Conflict between two opposing views on Federal participation in pollution abatement has been largely responsible for failure to enact any legislation to date. Also doubtful whether without such compromise as is proposed by House, a law reasonably agreeable to most interested parties would pass Congress this year. If bill is enacted substantially as amended by House, following points are mentioned as of interest to States and their civil subdivisions: (1) States will not receive allotments of money to help enforce their pollution laws by study or otherwise, though loans may be made under certain circumstances by R. F. C. (2) Neither States nor municipalities will receive grants-in-aid for construction of treatment plants. (3) States are permitted to borrow money for construction pur-

poses from R. F. C. if State health authority and Surgeon General first approve. (4) States will be able to obtain assistance from Public Health Service in connection with specific pollution problems. Such assistance may include investigations, surveys, and specific recommendations for correction. (5) States will be encouraged to enact uniform laws relating to water pollution and to undertake co-operative activities with their neighbors for control of pollution on interstate streams. (6) Municipalities may request Division of Water Pollution Control to make tests of water at bathing beaches and submit recommendations for correction if deleterious conditions are found. Only such money as is specifically appropriated for purpose may be expended for these tests however.—*P. H. E. A.*

Water Pollution in the United States. *Third Report of the Special Advisory Committee on Water Pollution.* National Resources Committee. U. S. Govt. Printing Office, Washington ('39). Comprehensive review of conditions of water pollution in U. S., and of technical, financial, and administrative problems involved in reduction of pollution. Material presented in reports in '35 and '37 revised and extended. Contains also new analysis of cost of a national pollution-abatement program. Section on "Sources of Water Pollution" deals with municipal sewage, mining waste, and industrial waste. Approx. 56% of pop. of U. S. disposes of its domestic waste through public sewerage systems. Remaining 44% is generally scattered and does not discharge large amounts of sewage. Mining waste consists mainly of acid drainage and culm from coal mines, brines from oil wells, and debris from hydraulic metal mining. Sealing of abandoned bituminous coal mines has considerably reduced acid waste in some areas. Oil-field brines are dealt with by sub-surface disposal or by dilution in streams or coastal waters. Improvements in methods of mining, supplemented by control measures, have reduced silting in streams resulting from hydraulic-mining debris. Industries mainly responsible for waste disposal problems are those concerned with foods and beverages, textiles and tanning products, chemical products, petroleum refinery products, ferrous and non-ferrous metals, rubber, paper, and illuminating gas. Tables and charts are given to show position and importance of each of these industries. In section on "The Effects of Water Pollution" materials responsible for pollution are divided into chemically inactive and chemically active substances (latter are subdivided into putrescible and non-putrescible) and bacteria. Major effects upon man of these polluting substances are tabulated. Estimates of cost of schemes for reducing pollution are given under regional headings in case of municipal waste and according to nature of industry in case of industrial wastes. In section on "Standards of Water Quality" table is given showing minimum requirements with regard to floating solids, suspended solids, turbidity, organic substances, coliform organisms, acids and alkalis, odors and tastes, for effluents discharged into Delaware R. Standards for quality of water for freshwater fish have been arrived at by correlating data obtained from existing literature and from field and lab. studies carried out under direction of U. S. Bureau of Fisheries. Sections dealing with administration and with public financing of pollution abatement. Recommendations are made for new state and new federal legislation. 3 appendixes deal respectively with state laws and regulations, estimates of cost for various types of water treatment plants, and reduction of pollution in Western European countries.—*W. P. R.*

Some Developments in the Water Pollution Research Program of the Public Health Service. J. K. HOSKINS. Pub. Health Repts. **55:** 893 (May 17, '40). *Sewage Treatment Studies:* Primary objective has been to determine factors which impair efficiency of activated sludge method of sewage purif. Predominant type organisms in process appear to be zoogleal. When aerated in pure culture, in clear synthetic medium, or sterilized sewage, these produce growth having activated sludge char-

acteristics such as flocculation, rapid settling, clear supernatant with high rates of oxidation, and total purif. of soluble organic matter. From this finding, has been possible to demonstrate exceedingly high rate of organic matter reduction as compared with removal rate of B.O.D. regularly observed in streams or dilution process. Has been possible to trace component rates of purif., including oxidation rate as distinguished from those of net absorption and synthesis of organic matter in activated sludge. Close similarity in characteristics and functions of the zoogleal bacteria found in activated sludge flocs and slime coatings of sewage sprinkling filters, appears to exist. For quick test, oxygen (O_2) used per gram of suspended matter during a short period of aeration of sewage-sludge mixture found to be better index of condition. Relation of fungus *Sphaerotilus* to sludge bulking being studied. Flourishes best under conditions detrimental to normal activity of zoogleal bacteria. In regard to O_2, found that: (1) modified azide procedure increases accuracy of B.O.D. test in presence of nitrites; (2) Winkler method of B.O.D. detn. of river muds may be quite inaccurate through interference of insoluble sulfides, or similar substances, with reagents, but may be removed by coagulation previous to test; and (3) D.O. saturation value of sewage approximately equal to that of clear water. *Stream Oxidation Study:* Most uncertain element in measuring rate of natural oxidation with B.O.D. test is O_2 demand by underlying sludge deposits. Experimental work has brought out effect of various factors on O_2 depletion and re-aeration. Re-aeration rates of high velocity polluted streams lower than that of unpolluted ones. *Scioto River Study:* Bact. biol. and biochem. studies made for 1 yr. to evaluate sewage treatment in definite terms of stream improvement. Data suggest old Imhoff tank sprinkling filter effluent less detrimental to river than that from new plant using plain sedimentation only. With complete activated sludge treatment, however, profound improvement occurred. Certain plankton organisms considered pollution indicators have been verified. *Inventory of Water and Sewage Treatment Plants:* Intended to help locate problems in these fields, record progress in their solution and aid engineering divisions of state health depts. *Ohio River Pollution Survey:* Authorized to determine corrective measures. Central ⅓ of watershed studied comprises 280 mi. of river plus tributaries and about 30,000 sq.mi. area. Proposed to complete upper and lower sections by end of '41. Mobile labs. supplement work of central and a floating lab. *Miscellaneous Activities:* Direct plate coliform counts being correlated with indices of standard procedure. Appears that former sufficiently accurate to justify serious consideration of shortened procedure when density of numbers is sufficient to provide accurate plate counts. Plankton life in acid mine waters restricted to certain specific forms. Methods of preparing plankton specimens for microscopic exam. and changes in same induced by formalin preservative, have been studied. Attempt made to evaluate dissolved O_2 contributed to water by definite species of algae.—*Ralph E. Noble.*

Pollution Control Work of the California State Div. of Fish and Game. PAUL A. SHAW. Munic. Sanit. **11:** 376 (Aug. '40). As no interstate contracts exist, California State Div. of Fish and Game is limited to: (1) enforcement of Federal laws; (2) enforcement of state laws; and (3) injunctions or private damage suits. Under Federal law, where navigable water may be affected, action can be taken to prohibit discharge of oil or refuse from vessels or shore plants, exclusive of that flowing from streets and sewers in liquid form. State Public Health Act and Sec. 481 of Fish and Game Code provide means of pollution control. Act is weak in enforcement features. Restricts pollution control to fish, plant life and bird life. In '39, due to low stream flows, many fish in Mokelumne R. killed after winery season opened. Wastes from such industries and celery packing plants subjected to control. Disposal of waste from fruit and vegetable canneries in Valley and Bay areas directly into state waters or

through sewers thereinto now subject to some control. Agreements between state and operators have been made to have such wastes disposed on land, thereby eliminating pollution of state waters. In fishing industries, "stick water" is principal pollution load after removal of fish oil and meal in reduction process. Recent studies show pollution from this source can be reduced 70% through coagulation process with sulfuric acid. In Bay dist., such pollution is equivalent to raw sewage from 5-million pop. during peak fishing days.—*Ralph E. Noble.*

First Year's Work of the Ohio River Pollution Survey. E. S. TISDALE. Ind. Eng. Chem.—News Ed. **18:** 619 (July 25, '40). Stream sanitation study conducted jointly by Corps of Engrs., U. S. Army, and U. S. Pub. Health Service in '39 covered over 30,000 sq.mi. in middle ⅓ of Ohio R. basin, including 280 sq.mi. of main river, 8 sub-drainage basins, 1,968 public water supply systems and purification plants, 1,968 sewerage systems and sewage treatment plants and 553 large industrial plants. More than 25,000 water samples were analyzed bacteriologically, chemically and biologically. Nearly ¼ of U. S. pop. lives in Ohio R. watershed. Broad objectives of survey include protection of public health, industrial uses of wastes, recreational assets, preservation of aquatic and wild life, navigation, agriculture and necessity of serving general public welfare. Use has been made of available current information on stream sanitation from existing federal, state and municipal organizations, industrial organizations and individuals. Work in '39 on industrial wastes comprised: collection of factual data on sources, character and amts. of wastes; detailed field studies, with T.V.A., of certain industries discharging typical or new types of wastes; and collection of data on wastes in certain basic industries for use in studies being made in the basin. Federal financial assistance and effective educational work have reduced stream pollution markedly in recent years, great improvements being noted in municipal sewage and industrial wastes, including acid mine drainage. Treatment of urban sewage in U. S. increased from 30% in '32 in 60% in '38. Survey is not research study but intended to form basis for comprehensive plan for abatement of existing pollution and control of future pollution, pioneer project for large watershed.—*Selma Gottlieb.*

Stream Pollution Control Advances in Indiana. B. A. POOLE. Munic. San. **11:** 282 (June '40). First Ind. pollution (pol.) control law, passed in '01, provided that no polluting material could be discharged into stream by any factory without written permission from State Bd. of Health. Exemption of municipal waste from provisions constituted weakness. McGinnis law of '09, repealing act of '01, empowered State Bd. of Health to investigate stream pol. upon petition of a city common council or bd. of health, county commissioners or trustee of any township. If stream pol. was found, State Bd. was authorized to order its abatement. Streams forming state boundaries were excluded as also were out-of-state streams polluted upstream from Ind. Third law, '27, empowered State Bd. to investigate stream pol. conditions and order abatement. Because Lake Mich. and streams emptying into it from Ind. or Ill. were exempted, some authorities question constitutionality of law. Ind.'s last and most workable stream control law, '35, empowered Dept. of Commerce and Industries to investigate conditions of water pol. and order abatement. Requires adoption of standards of purity and standards for effluents discharged to water courses through any sewer or drain. Appeal is made to a Pollution Hearing Board before coming to local courts. Series of laws aided program of stream pol. abatement. From '20 to '40, 16 mi. to 680 mi. of stream pol. have been improved. Attention has been confined largely to pol. from municipal sewers. Cost of projects ranged from less than $2,000,000 in '20 to over $29,000,000 in '33. From '20 to '40, respectively, 1.8% to 72.0% of urban population have become served by sewage treatment facilities. Accomplished removal of phenols from waste of steel

mills and oil refineries is important. Progress has been made in elimination of pol. from cannery, packing, milk and paper wastes. Much work remains to be done on wastes from above sources and from distilleries, strawboard plants, mines and oil wells. In general, industries assume co-operative attitude.—*Ralph E. Noble.*

Diagnosis for a Sick River. EDWARD J. CLEARY. Eng. News-Rec. **124:** 21: 52 ('40). "Now under way in Ohio River drainage basin is perhaps greatest stream sanitation study ever attempted. No precedent existed for work of this magnitude, involving an area of 204,000 sq.mi. included in 14 states." As described in article, organization of survey, its methods, and its objectives provide new chapter in stream pollution abatement progress. Authorization was given in Rivers and Harbor Act of August, 1937, which provided that Secretary of War "cause a survey to be made of the Ohio River and its tributaries to ascertain what pollutive substances are being deposited, directly or indirectly, therein and the sources and extent of such deposits and with a view to determining the most feasible method of correcting and eliminating the pollution of these streams." At request of Secretary of War, Public Health Service was authorized to undertake the following parts of the study: (1) Make lab. investigations. (2) Collect factual data on pollution. (3) Determine character of water in main and tributary streams. (4) Determine extent of treatment required. (5) Carry out all other necessary studies to determine existing and future conditions bearing on pollution. Hydrometric data to be used in survey will be furnished by U. S. Corps of Engineers, who not only have records of many years' standing but are also specially qualified to carry on complex studies of stream flow. Ohio River survey is directed toward practical objective of determining what conditions are, and recommending means by which they should be improved. Organized for efficiency and designed to integrate efforts and facilities of Federal agencies and, wherever possible, enlist cooperative aid of state health depts. Organization chart of Ohio River Committee, general plan, short outline of lab. studies, field surveys, and hydrometric studies given. While not practicable to draw conclusions from results thus far obtained, some general trends can be evaluated. "Comparing Ohio River water in middle third section with respect to suitability for purification by ordinary rapid sand filtration coupled with post-chlorination, roughly estimated that under most unfavorable monthly mean conditions of '39 about 35% of waters examined would be considered as suitable for treatment, 20% as doubtful in this respect, and 45% as clearly unsuitable. On basis of D.O., about 40% would be rated as satisfactory, 20% as doubtful, and 40% as clearly unsatisfactory. Thus it appears, from two criteria combined, that about 35 to 40% of waters examined during Aug. were in reasonably good sanitary condition, remainder being either grossly polluted or of doubtful quality reflecting conditions requiring correction."—*P. H. E. A.*

The Public Health [Drainage of Trade Premises] Act of 1937. J. H. GARNER. Wtr. & Wtr. Eng. (Br.) **43:** 15 (Jan. '41). Act, which came into force on July 1, '38 is first piece of public legislation, designed to promote purif. of rivers, passed by Parliament since Rivers Pollution Prevention Act of 1876. Permanent improvement in purity of streams flowing through industrial areas can best be obtained by discharging industrial wastes into sewers and treating them with domestic sewage of district. Act places local authorities under general obligation to receive and deal with industrial wastes. For successful working of Act, co-operation is required between mfrs. and local authorities, and among mfrs.—*H. E. Babbitt.*

Investigation of the Pollution of the Fox and East Rivers and of Green Bay in the Vicinity of the City of Green Bay. Report of Wisconsin State Committee on Water Pollution and State Bd. of Health in collaboration with Green Bay Metropolitan Sewerage Commission. ('38–'39). Report presents results of pollution

survey of portion of lower Fox, East River (tributary to Fox), and Green Bay, along with special studies on waste sulfite liquor. Purpose of survey was to determine cause of 2 problems which existed in vicinity of Green Bay, Wis.: (1) "stench which developed in East River each year during summer months; and (2) death of fish in nets of commercial fishermen along eastern shore of Green Bay in winter months." Data obtained in survey, results of which are included in detail in report, consisted of composite samples of various waters for complete chem. analysis and comprehensive biol. and physical observations. Under topic of general information, pollution history of waters in vicinity are discussed. As early as '25 and '26, pollution surveys of lower Fox R. were conducted, results of which showed that intolerable conditions existed for aquatic life below Wrightstown to Green Bay during critical summer months. Followed by pollution abatement program instigated by state committee on water pollution and state board of health. Resulted in building of interceptors and treatment works for sewage by all municipalities (last construction completed early in '40). Industrial wastes which discharge into river include those from numerous pulp and paper mills, wood-products plants, woolen and knitting mills, packing and rendering plants, milk factories, canneries, gas plants, and a beet-sugar factory. Relative to East R., before Jan. '35, it received domestic sewage from city of Green Bay as well as waste from packing plant, gas plant, and 2 paper mills. Wastes now discharging into stream were found to include waste sulfite liquor, gas-plant, garbage and privy refuse, and domestic sewage during periods of high rainfall. Green Bay receives discharge of Fox and East R. To determine effect of pollution to fish and other aquatic life, total of 86 sampling stations were established in Bay. Amt. and extent of pollution were determined by D.O. and B.O.D. Physical and chem. conditions of water were ascertained, along with thorough study of net plankton plants and animals. Studies of this body of water definitely indicated that "no relief can be expected from conditions observed in Green Bay until equipment which will remove at least major portion of oxygen-consuming material in waste sulfite liquor is installed at all mills discharging waste sulfite liquor into lower Fox R." Conditions observed showed location of zone of de-oxygenation at various temp. extremes, change in location of which varied from mouth of Fox R. in summer to outer bay in the winter. Seasonal change is attributed to change in rate of B.O.D. of waste sulfite liquor, it being much higher at 20°C., and with only a slight perceptible lag, and much lower at 0°C., with a lag extending over a period of 5 to 10 days. It is movement of zone of max. de-oxygenation out into bay which causes lowering of D.O. in water under ice, and hence death of fish. Stream-flow data obtained in previous surveys showed that Fox R. and Green Bay caused reversals of current in East R. Conditions of Fox R. were therefore studied to determine their effect on East R. Samples from routine sampling stations showed definite pollution in this river. D.O. dropped to below critical conditions at various points when water was at its warmest. From data obtained, was concluded that total oxygen-demanding materials discharged into Fox River were: domestic sewage, 7% of total; waste sulfite liquor, 88%; and whitewater and miscellaneous waste 5%. Biol. observations showed that in some places enough organic content was present to support fairly good growth of muck-loving animals. Concluded that: "Fox R. will remain in its present highly polluted condition throughout its entire length, from Appleton, Wis., to mouth at Green Bay, so long as sulfite mills continue to discharge their wastes into stream. Major portion of oxygen demand of waste must be removed if serious pollution problem is to be eliminated." Determination of cause or source of stench in East R. was major reason for conducting survey. Samples collected at hourly intervals at numerous survey stations showed that East R. water has zone of low oxygen content which moves back and forth with surges of current. Correlation between oxygen demand of river water and waste sulfite

liquor definitely proves that latter is cause of oxygen depletion. Comprehensive exam. of bottom conditions was made and led to conclusion that lower East R. is in nature of settling basin, depositing sewage solids, paper fibers, and clay and silt from flood waters. These bottom materials, though not source of odor, do act as a seeding medium to produce stench. Gas produced by bottom materials consisted mainly of non-odor-producing carbon dioxide and methane. Under certain conditions that may exist in streams or lakes, hydrogen sulfide can be produced either by decay of nitrogenous material or by reduction of sulfur-containing compounds. Expts. conducted in survey finally proved that: "hydrogen sulfide production and resulting odor in East R. is caused by bacterial reduction of sulfur compounds contained in waste sulfite liquor." Hence, recommended that: "first and most essential step in removal of stench from East R. is elimination of discharge of waste sulfite liquor at mouth of river." Finally, report presents detailed study of various constituents in waste sulfite liquor. As result, was shown that in 8 days an ultimate of 30 p.p.m. of hydrogen sulfide is generated by waste sulfite liquor under anaerobic conditions, whereas concentrations of 4 to 5 p.p.m. of hydrogen sulfide in East R. are causing nuisance problem. Appears that carbohydrates, or wood sugars, serve as energy food for sulfur-compound-reducing organisms. Complete treatment of waste will require removal or stablization of wood sugars. Research to accomplish purpose is recommended.—*P. H. E. A.*

Occurrence and Cause of Pollution in Gray's Harbor. ARNE ERIKSEN AND LAWRENCE D. TOWNSEND. Wash. State Pol. Com., Pollution Ser., Bul. No. 2 ('40). Pollution mainly due to 4,600,000 gal. of waste sulfite liquor which flowed into harbor daily from neighboring pulp mill. B.O.D. of 6,600 p.p.m. more than 9 times pollution by towns and other factories. Low D.O. concns. occurred only in July, Aug. and Sept., when pulp mill was operating and river discharge rates into harbor were below 4,000 sec.-ft. Min. D.O. in percentage of satn. was 0.0196 D—0.875 when discharge rate D of river in sec.-ft. was less than 4,000. Lowest D.O. occurred in water of chlorine range 8 to 12. Min. concn. of D.O. varied with tidal current. Atmospheric re-aeration accounts for part of excess of oxygen demand over amt. of O available from the river water and sea water. Amt. of phytoplankton too small for appreciable effect on re-aeration. Extensive mud flats of harbor had no effect on D.O. pH of waste sulfite liquor was 1.90. Recommended that discharge of waste sulfite liquor into Gray's Harbor be controlled in such a way that D.O. of harbor water never falls below 5 p.p.m.—*C. A.*

Pollution of Boston Harbor. SAMUEL A. GREELEY. J. Boston Soc. Civ. Engrs. **27**: 2: 102 ('40). Describes extent and degree of pollution and effect on shore line, recreational, and bathing areas. 3 series of bact. analyses made by State Department of Health reviewed and results shown graphically as to total count and sleeking. Index of 1,000 coliform organisms per 100 ml. of water taken as minimum no. to indicate excessive contamination. Series used were results of sampling during '30, '35, and '36. Graphs show clearly extent of harbor affected by sewage from metropolitan Boston. Some sampling stations near bathing beaches showed max. of 100,000 coliform organisms to 100 ml. with average from 1,735 to 11,000. Effect of tide on dispersion of contamination is also shown graphically. Illustrated graphs also show roughly what can be expected by '55 without improvement in sewage treatment for Boston area.—*P. H. E. A.*

A Biological Survey of the Allegheny and Chemung Watersheds. V. Chemical Investigation of the Allegheny and Chemung Watersheds. H. M. FAIGENBAUM. N. Y. State Conserv. Dept. Biol. Survey No. 12:113 ('38). Pollution studies, involving detns. of free CO_2, dissolved O_2, alky., chlorides and H-ion concn., were made on Allegheny R. and 18 of its tributaries; Chemung River and 9 of its tributaries;

and all important lakes, ponds and hatchery waters. The location and types of pollution, including sewage, milk and milk products, oil, tanning, gravel-washer and miscellaneous wastes are tabulated and effects of oil and gravel-washer wastes are discussed.—*C. A.*

A Biological Survey of the Lower Hudson Watershed. V. Chemical Investigation of the Lower Hudson Area. H. M. Faigenbaum. N. Y. State Conserv. Dept., Biol. Survey No. 11: 146 ('37) (*Supplement to 26th Ann. Rept.*). Pollution studies, involving detns. of free CO_2, dissolved O_2, alkalinity and H-ion concn., as well as measurements of temp. and depth, were made on Hudson R., 7 major and 17 minor tributaries, Bronx R. and 3 N. J. tributaries. Analyses were also made of 110 lakes and ponds and hatchery field station waters, in use or proposed. Effects of principal types of pollution are discussed, including those resulting from sewage, milk and milk products, laundry wastes, bleaching, finishing and dyeing wastes, paper and associated wastes and miscellaneous wastes.—*C. A.*

Pollution of Sea Water by Discharge of Sewage. F. Dienert and A. Guillerd. Ann. d'Hyg. Pub., Indust. et Sociale. **18:** 209 ('40). Commonly, but erroneously, believed that sea water is antiseptic and inimical to pathogenic organisms. Present investigation demonstrates necessity of making thorough study of local conditions when proposal to discharge sewage into sea comes under discussion. Direction and force of any currents and their possible change of direction, expansion, route and degree of spread by tests with fluorescein, ratio of phytoplankton to zooplankton, prevailing winds and their force must be taken into account. After installation, frequent analyses of waters near shore will be called for to determine whether pollution is taking place. [Abstractor when asked to investigate effect of sea water on fecal bacteria in Hong Kong, in 1920, found that *V. cholerae, Bact. typhosum* and other pathogens thrived readily in water of harbor and, consequently, that there was no little danger from natives defecating indiscriminately from sampans moored there.]—*B. H.*

Oil Field Waste Water Disposal. W. Humphreys and A. M. Rawn. W. W. & Sew. **87:** 341 (Aug. '40). High salinity and oil content of wastes from Southern Calif. oil fields prohibited disposal in water courses or to abandoned wells. Oil companies combined to form waste disposal organizations which treat wastes to recover oil, clarify wastes, maintain feeder mains, and operate outfalls to sea. Characteristics of wastes, construction and operation of treatment plants, and costs are discussed.—*H. E. Hudson, Jr.*

Treatment and Control of Industrial Wastes. Milton P. Adams. Can. Engr. **78:** 10: 50 (Oct. '40). Mich. Stream Control Com. was created in '29 to strengthen state's position in dealing with pollution. Composed of comr. of health, director of conservation, state highway comr., comr. of agriculture, and attorney general. Statute confers broad powers on com., including authority to exercise wide discretion in setting up stream standards and pollution restrictions. Installation of munic. sewage plants often discloses other unsuspected sources of pollution which were hidden by major pollution. Resistance of industry to reasonable pollution-control program is now much less in evidence. When double objective of reduced pollution and salvaged material can be presented, less difficulty is encountered in securing co-operation. Frequent inspections, usually without notice, are required to secure efficient operation after plants have been installed. Little can be accomplished without research. Sufficient detailed field and lab. work has not been carried out to recommend state-wide or watershed stream standards, but objectives include freedom from sludge deposits, pH value of discharged wastes between 5.8 and 8.2, freedom from unnatural color, oil-films and toxic substances, stability, and min. of 4.0 p.p.m. D.O. in receiving waters. Recommended requirements summarized for following

wastes: beet sugar, pulp and paper, canning, tannery, milk products, oil-field and other brines, phenols, metal-treating and plating, textile, and oil. Co-operation of industry is important. Inducing managements to act in public interest is salesmanship at its best.—*R. E. Thompson.*

Improvements in or Relating to the Treatment of Waste Sulfite Liquor. ANON. Norsk Hydro-Elektrisk Kvaelstofaktieselskab. B.P. 519, 848. Bases are removed from waste sulfite liquor by passing liquor through acid cation exchanger. pH value is reduced from 2.5-3 to below 1. If liquor so obtained is neutralized with ammonia, tanning product, purer than those previously produced from waste liquor, is obtained. By evaporating treated liquor and heating to temp. not above 130°C., cation-exchange materials are produced. Cation-exchange materials are also produced by drying under vacuum. Cation-exchangers can be used to recover bases from further batch of liquor. Sugar in liquor is preferably fermented by yeasts before treatment with cation-exchange materials.—*W. P. R.*

Process for the Purification of Sulfite Waste Liquor. ANON. I. G. Farbenindustrie A.-G. F.P. 844, 254. Waste sulfite liquor may be purified and color removed by treatment with colloidal solutions of heavy earth metals, e.g. gels of aluminum and zirconium oxides, after removal of calcium and iron salts. Colloidal solutions are added until sample filtrate no longer forms precipitate on addition of further reagent. Filtrate, pale yellow in color, can be evaporated, and yellow non-hygroscopic powder is obtained. Powder may be used in mfr. of adhesives, in dyeing and bleaching of wool, and in mfr. of emulsifiers, soaps and tanning materials.—*W. P. R.*

The Economic Disposal of Waste Sulfite Liquor. G. H. TOMLINSON AND L. S. WILCOXSON. Paper Tr. J. **110:** TAPPI Sect. 209 ('40). Authors have found that, if magnesium oxide is used in place of calcium oxide as base of cooking liquor in the sulfite-pulp process, possible to recover and re-use chemicals as well as to recover waste heat in form of steam. Magnesium sulfate in waste water is reduced directly to an oxide with liberation of sulfur dioxide instead of forming sulfides and other sulfur compounds which cause trouble in recovery of chemicals from waste water. Pilot plant, using a magnesia-base liquor, was installed at a mill in Cornwall, Ont., in '37. Operations involved in process are preparation of magnesia-base cooking acid, preparation of pulp with magnesia-base acid, reclamation, neutralization, concentration, and burning of residual liquor, and recovery of magnesia and sulfur. Each operation described. Quantities of materials which would be required for plant producing 100 tons of pulp per day are given.—*W. P. R.*

Recovery of Materials in the Treatment of Trade Waste Waters. M. PRUSS. Rev. Univ. Min. (Fr.) **15:** 630 ('39). Author emphasizes importance of recovery not only of materials dissolved or in suspension in trade waste waters but of water itself. Cooling and condensing water can easily be cooled, freed from oil, and re-used; and waste waters from coal washing, paper making, and beet sugar mfr. can be re-used after simple treatment. When materials are to be recovered, important that solns. or suspensions should not be too dilute. In Germany, fats recovered from abattoir wastes, blood kept separate and used in mfr. of cattle food, and solid wastes used in mfr. of fertilizer. Similar uses could be made of wastes from food industries such as breweries, distilleries, and sugar factories. In milk products factories, whey and waste milk can be used to produce valuable fodder; or albumen, lactose, and lactic acid can be recovered. Waste of acid in pickling liquors can be avoided by re-using liquors in closed circuit. Diagram given of plant designed for recovery of ferrous sulfate from waste waters from pickling with sulfuric acid. Preliminary washing tank introduced between pickling bath and final washing tank reduces amt. of polluting matter in effluent from final rinsing tank. Contents of preliminary

rinsing tank can be re-used in pickling tank. In Ruhr dist., waste waters from pickling with hydrochloric acid collected in 1 factory for treatment. Particularly valuable in production of pigments. Copper can be recovered from pickling waste waters by passing waters over iron turnings or by electrolysis; former process can be accelerated by agitation of turnings. Phenol can be recovered from waste waters of coke works and similar factories by washing with benzole; Koppers process of removing phenol by current of gas used successfully for treating gas-washing water. Slurry from coal-washing can be dried in underdrained settling tanks, mixed with coke dust or further dried by vacuum filtration, and used as fuel. 200,000 tons (Metric) of coal sludge recovered annually from water of Emscher R. in settling tanks at Karnap; sludge dried and used as fuel. Grease can be recovered from wool-washing waters by treatment with sulfuric acid; emulsified grease can be separated by aeration with compressed air. Waste waters from compressed yeast factories evaporated in multi-stage evaporators under reduced pressure; concentrated vinasses calcined and used in mfr. of fertilizer. Evapn. often only satisfactory method of dealing with very polluted waste waters, such as those from cellulose factories. Alcohol, furfurol, tanning extracts, and binding material for briquettes or for roads obtained from these wastes. Fibers recovered from paper factories' wastes by flotation. Process in use in Germany for production of soap and fats from coal. First stage similar to first stage of production of benzene by Fischer-Tropsch process; paraffin, by-product of process, converted by oxidation to fatty acids from which soaps and fats manufactured; lower fatty acids at present lost in waste waters from oxidation process, but recovery might be made to pay if processes for converting them into useful materials were devised. —*W. P. R.*

Ten Years of Phenol Recovery From the Gas Liquors of Coke Works in the Rhine-Westphalian Industrial District. H. WIEGMANN. Gluckauf. (Ger.) **75:** 965 ('39). To prevent pollution of Emscher and Rhine by waste waters from coke by-product works, construction of phenol recovery plants proceeded rapidly from '27 to '30. In '30 and following years, however, amt. of coke produced diminished and did not reach '29 level until '37. Amt. of phenol and cresol recovered continued to increase until '35, decreased slightly in '36 and '37, and rose rapidly in '39 when 15 recovery plants were in operation. Expected that over 3,000 tons (Metric) of phenol will be recovered in '40 as compared with 2,400 in '39. Production of coke increased to over 25 mil. tons in '38 and '39; waste waters should contain about 10,000 tons of phenols. If complete recovery were possible, large proportion of phenol and cresol required in Germany could be supplied from this source; recovery, however, only partial, and costly. Improved methods of operation of coke ovens have reduced amt. of phenol in waste waters, thus reducing polluting effect, but adding to cost of recovery. Phenol recovery plants in Emscher dist. erected by Emschergenossenschaft and operated by coke works. Gas liquor washed with benzole, and phenol extracted from benzole with soda lye; phenolate lye collected by Emschergenossenschaft and conveyed to one of two plants where phenols separated and caustic soda regenerated and returned to coke works. Author gives brief survey of improvements effected in design and operation of recovery plants during recent years. In one plant mixing pumps used instead of countercurrent washers for removing phenol from liquor by benzole. Centrifugal separators used to remove particles of tar and dust from gas liquor before washing with benzole. Exptl. plant constructed using similar separators for separating mixtures of benzole and water and benzole and lye. Found advisable to distil part of benzole before re-use to remove dissolved tar and oils. Methods of recovering benzole remaining in gas liquor after removal of phenol described. Emschergenossenschaft should, in '40, have 16 phenol recovery plants in operation; 2 plants also planned for Ruhr dist. and 3 for Lippe dist.

These should produce about 4,200 tons of phenol and cresol and relieve streams of that amt. of pollution. Investigations indicated that decomposition of phenol in Rhine generally rapid, but rate much reduced in cold weather. Though, according to Kalabina, fish can survive exposure to phenol concs. of 4–15 mg. per liter, taste of flesh may be affected by concs. above 0.02 mg. per liter. Other constituents of gas liquor which may damage fish, e.g. naphthalene, resins, and cyanides, also removed by washing with benzole. Judged by permanganate demand, polluting effect of coke works waste waters reduced by about two-thirds by washing with benzole.—*W. P. R.*

Recovering Tin From Waste Phosphate Liquors. C. C. DOWNIE. Silk & Rayon. **13:** 962 ('39). Discusses recovery of tin compounds from waste phosphate liquors from loading of silk. Owing to large no. of methods of loading which are employed, no one process of recovery is universally applicable, but method is described which should be suitable for waste waters from all types of phosphate treatment. Filtration through active alumina removes part but not all of tin. Tin may then be drawn into solution as sulfide by washing alumina and tin precipitate with sodium sulfide containing free sulfur. Alumina and sulfur are then removed by vacuum filtration through ceramic plate. Clear solution of tin sulfide in sodium sulfide is acidified with hydrochloric acid and hydrogen sulfide produced is burned. Precipitated tin sulfide is converted to tin oxide by "roasting" in steam chest, and oxide is then converted to tin chloride by solution in a minimum of hydrochloric acid. Alumina can be used repeatedly so that costs involved are those of sodium sulfide and acid. Only other metals which could be removed with tin are arsenic and antimony, and these should not be found in waste phosphate liquor. More recently tin has been separated from sodium sulfide solution by electrolysis. Hoped that will be possible to electrolyze wastes directly and to abandon preliminary filtration through alumina.—*W. P. R.*

HYDROLOGY

Water Resources of the Mid-Continent Area. GEORGE S. KNAPP. Civ. Eng. **10:** 653 (Oct. '40). Mid-Continent area embraces transition zone between humid eastern and arid western parts of U. S. Region of great change, from forest-covered hills along Miss. R. to vast, smooth, and treeless plains extending more than 200 mi. eastward from Rocky Mts. From standpoint of water problems resulting from variations in rainfall, deviations from mean annual amounts probably of more importance to engr. than westward diminution of averages. Study recently made of probable water supply for proposed irrigation project within area, where terrain is rolling and some parts of it almost hilly. Certain streams flowing eastward across area rise in high mts. along continental divide. Over most of remainder, natural storage, except in soil, almost nonexistent. Probably in no other part of U. S. are water problems incident to occupation of country by man as varied as those in area. Floods on tributary streams continuing problem. Those crossing area to make homes in western part found it necessary to irrigate deep rich soils to make them productive. Water power never assumed a status of major importance. Rainfall trends appear not to follow consistent downward trends of runoff. Temps., even more than runoff or rainfall, show definite and consistent tendencies throughout entire area. Since temp. trends have been definitely upward for more than 50 yr., and are still going up at a relatively rapid rate, appears that we are confronted with no short weather cycle.—*H. E. Babbitt.*

Reliability of Station-Year Rainfall-Frequency Determinations. KATHARINE CLARKE-HAFSTAD. Proc. A. S. C. E. **66:** 1603 (Nov. '40). Only feasible method for predicting probable fre-

quencies of certain amounts of rainfall is one based on statistical study of precipitation history. Method consists essentially of collecting all rainfall records, of whatever length, for an area, and treating sum of all records for all stations (called "station-year record") as if it were single record for mid-point of area under consideration. Max. rainfall to be expected with certain frequency is termed "pluvial index" for area. Irregularity of station spacing will seriously affect values of ave. frequency in areas with non-uniform rainfall characteristics. Wide spacing of stations would suffice to give fairly accurate value of ave. frequency of rainfall quantities if all storms were of large-area homogeneous type. Usual formula for standard error of mean cannot be applied to frequencies of rainfall because they do not form a normal distribution, but rather discontinuous one of Poisson type. If average no. of stations recording given depth in storm day were same for every year, and if nos. of storm days per year constituted random series, then value of N_d would be equal to N_a for total years of data.

$$N_d = \left[\sigma_s \div \frac{\sigma_1}{\sqrt{s}} \right]^2$$

in which N_a = ave. no. of stations; N_d = no. of stations on ave. receiving given amount in each storm day; σ_s = standard deviation of s; σ_1 = standard deviation for individual numbers; and s = no. of numbers in group. Calculation of N_d has been made from rainfall data for 2 areas in U. S. in different climatic regions. Availability of either value of N_a or N_d makes possible approx. answer to question regarding equivalence of station-year record to record of same length for single station. Although true reliability of frequency values should be determined on basis of degree of persistence in data, it is possible to give some indication of reliability from total no. of occurrences of given rainfall depth appearing in station-year record. *Ibid.* **67:** 129 (Jan. '41). PAUL V. HODGES: In determination of probable max. floods to be expected in different parts of country, pluvial indexes and their standard errors give basis from which comparisons and computations can be made. Paper is of considerable assistance and value in proper appraisal of records of storm rainfall over eastern half of U. S. To determine probable max. flood to be expected on Grand R. in northwestern S. D., "Hydrograph Method" was used and compared with largest floods of nearby streams. Station-year method of determining accuracy of rainfall frequency gives solution of standard error of frequency of rainfall as it occurs at particular stations. Sizes of probable max. floods to be expected, as determined by using pluvial index, adjusted for probable error, and compared with max. floods of nearby streams indicate fairly close agreement and show that available data give fair criterion for similar studies. *Ibid.* **67:** 255, 474, 665 (Feb., Mar., Apr. '41). C. S. JARVIS: Station-year approach to rainfall frequencies, magnitudes, and normal patterns of distribution, intensity, and recurrence long been accepted with some reservations and misgivings. Perhaps lack of perception will account for writer's inability to reconcile some minor details thus far, but he indorses paper as distinct scientific achievement. HOWARD W. BROD: Two fundamental weaknesses in station-year method which restrict applicability to very limited class of data: (1) variation of seasonal rainfall; and (2) dissimilarity of rainfall stations. Inadvisability of using nominal, or published, 24-hr. rainfalls as basis of frequency study indisputable. Subject of rainfall probabilities of such great importance to eng. profession that it would undoubtedly prove profitable for some organization to conduct investigation of rainfall probabilities for various locations throughout world. MERRILL BERNARD: Visualize a table having area confined within raised edge measuring 12′ by 12′. Table top intended to represent region of meterological homogeneity. Next, prepare 3 sets of concentric rings of light metal, symmetrically spaced and held rigidly in place. Consider differences in diams. to fix widths of concentric bands between rings (isohyets) of each "quoit" (storm). Without going into mechanical detail, assume means of

injecting storm quoits to, and on, table with impersonal result of mechanically thrown dice, or under assumption that quoit, having had energy applied to it, is under perfectly balanced compensative influences so that it can come to rest in any position on table with complete fortuity. At beginning of initial minute (year) of record, small upright peg (station) placed in arbitrary position on table (region). With only one peg on table, by far greater no. of throws will miss peg (no rain recorded at station) No. of times peg falls between isohyets of greater diam. will be in proportion to opportunity afforded by greater area of concentric bands between rings (isohyets). Analogy between table top and region strengthened somewhat if former considered covered with green baiz and outline of each quoit made with chalk, as each throw comes to rest. Result at end of complete series of throws will be completely covered table top (regional map) with superimposed storm patterns giving the same impression as that gained by superimposing maps prepared by Miami Conservancy Dist. As storm rainfall data are made more generally available, statistical methods such as proposed in paper will become basis for much sounder evaluation of magnitude and frequency than has hitherto been possible. CHARLES F. RUGG: One of most serious defects of station-year method is lack of real significance. For watershed containing several stations, simultaneous rainfall at all stations needed to estimate flood. If there were absolute dependence between stations, 50-yr. rain would occur at all of them at same time. Once frequency of storms of region determined, frequency of rainfall at either single station or average over given area can be compared. EUGENE L. GRANT: Station-year method presents 2 questions which constitute challenge to student of statistical technique. One is whether or not stations used are too far apart to be subject to same cause system with regard to storms of duration and intensity under consideration. Other is whether the stations used are so close together that same storm has been counted more than once. Station-year method particularly well adapted to dealing with high-intensity storms of short duration. Greater the intensity and shorter the duration, larger will be area covered by individual storm.—*H. E. Babbitt.*

Sixty-Year Rainfall Record Analyzed. HUGH F. KENNISON. Civ. Eng. **10:** 709 (Nov. '40). Study deals with relation between intensity of rainfall and frequency of recurrence for extensive rainfalls of various durations found in 60-yr. record for Chestnut Hill Reservoir. Results of calculations differ somewhat from those secured 10 yr. ago, using 50-year base. So results may be applied to extended drainage areas, durations up to 72 hr. have been used in analysis. Rate of precipitation for any significant fractional period, during a storm, is seldom, if ever, constant. Average rates are used as though rainfall occurred at constant rate equal to average for period of duration considered. To obtain equation and curve for maximum ave. intensities of rainfall likely to occur in period as short as 1 yr., necessary to obtain 60 highest rates in each of assumed duration periods occurring in entire 60 yr. of record. For most localities, relationship between intensity of rainfall and duration seems to follow straight line when points are plotted on log-log paper. Final empirical equation selected to represent data for 60-yr. record at Chestnut Hill is $i = \frac{15.6(1.6\ F - 0.6)^{0.22}}{(t + 6)^{0.7}}$ in which i is intensity of rainfall in in. per hr., F is frequency in yr., and t is duration in min. Max. deviation for 1-yr. frequency curve is 3.15%; for 10-yr. curve, 5.2%; and for 30-yr. curve, 10.1%. Point that deviated 14.4% from 60-yr. curve falls on 100-yr. curve.—*H. E. Babbitt.*

Surface Runoff Determinations From Rainfall Without Using Coefficients. W. W. HORNER AND S. W. JENS. Proc. A. S. C. E. **67:** 533 (Apr. '41). Where excess rainfall to be determined by subtracting infiltration rates from precipitation rates, engr. must know pattern of precipitation occurrence. If he is to utilize hourly rainfall rates, he must do it

with understanding of manner in which precipitation actually occurs, on the average within the hour. Robert E. Horton defined infiltration capac. as "maximum rate at which soil, when in a given condition, can absorb falling rain." Results of research indicate that: infiltration capac.: (1) varies little with surface slope; (2) probably varies materially with soil porosity and with soil moisture, possibly with soil moisture deficiency below field capac.; (3) may change rapidly with alteration of soil surface condition such as may occur under puddling action of rain impact, or under erosion and in working of fines where soil is not protected by good vegetal cover; (4) may be quite different for bare cultivated soils as compared with grass or other good vegetal cover; and (5) for bare soils, may vary with precipitation intensity, but, under good vegetal cover, relatively independent of intensity. Methodology for definite technique through which new principles and newly derived data may be applied to evaluation of surface runoff under specific conditions recently developed by writers. Essential stages involved in procedure as follows: (1) Delineation of precipitation pattern from which surface runoff to be evaluated. (2) Choice of basic curve of infiltration capac. (3) Adjustment of infiltration capacity values to antecedent conditions and precipitation pattern. (4) Determination of rate of production of excess rainfall. (5) Interception, depression storage, and infiltration out of surface detention. (6) Translation of mass surface runoff to hydrograph form. Second part of paper intended to accomplish two objectives: (1) to permit better visualization of various factors and processes discussed in first part, by actually applying them to small restricted area of conventional type, such as a developed city block; and (2) to show character of runoff that will occur from such conventional area, since hydrograph will differ because of differences in certain controlling variables. After producing actual synthetic hydrograph for each combination of conditions, proposed to discuss relation of peak flow to mean rainfall in terms of accepted definition of coef. of runoff. As to large areas: (1) precipitation patterns can be prepared for each important sub-basin preferably in units not exceeding 1,000 sq.mi.; (2) infiltration capac. values reasonably well related to actual soil and cover conditions can be accumulated separately for each sub-basin, and can be matched with pertinent precipitation pattern in logical manner; (3) from such combination, rate of production of surface runoff from each sub-basin will be developed in order and manner in which it would actually occur; and (4) diagram of surface runoff can then be translated into hydrograph of stream flow at any particular point in each sub-basin through unit graph or proper evaluation of surface detention and channel storage. —*H. E. Babbitt.*

Transient Flood Peaks. HENRY B. LYNCH. Proc. A. S. C. E. **65:** 1605 (Nov. '39); *Discussion.* (*See* Jour. A. W. W. A. **32:** 2093 ('40)). *Author's Closure*: *Ibid.* **66:** 1665 (Nov. '40). Discussion has revealed 3 basically different explanations to account for observed phenomena: (1) that large cross-sections resulted from retardation of stream flow, as it passed down channels, and its consequent accumulation; (2) that these flows were slow-moving bodies of water, very heavily loaded with debris and advancing somewhat as mud flow; and (3) that cross-sectional areas of channels were temporarily greatly reduced by accumulations of debris. First explanation is that adopted by writer. Second proceeds upon assumptions of ave. velocity and ratio of volume of water to debris which have been given variously by different writers. Third calls for positive physical elevation of stream beds from 6′ to 20′ throughout almost entire length of channels.—*H. E. Babbitt.*

Hurricane Floods of September 1938. C. G. PAULSEN, B. L. BIGWOOD, A. W. HARRINGTON, O. W. HARTWELL AND H. B. KINNISON. U. S. Geol. Survey, Water Supply Paper 867 ('40). Floods described generally contemporaneous with passage of severe West Indian hurricane over Long Island and New England. Floods came as culmination

of 4-day period of rainfall, beginning on Sept. 17, and continuing with generally increasing intensity, ending abruptly late on Sept. 21 with passing of hurricane. Rainfall during period was greatest in central New England, exceeding 17″ locally and averaging 11.5″ over 10,000-sq.mi. area, characterizing it as greatest storm on record in region. Many streams in Merrimack, Thames, lower Connecticut, and Housatonic River Basins reached record-breaking crest stages and discharges. In some of smaller streams, rates of flow of 400 to 500 sec.-ft. per sq.mi. were measured, with volumes of direct runoff as high as 10″. Results of computations of absorption of rainfall, included in report, indicated marked tendency for greater infiltration in lower coastal areas than in steep mountainous areas. Hurricane was accompanied by record-breaking ocean levels along coast between N. Y. City and Cape Cod, level being highest in R. I. Report presents detailed records of stage and discharge for flood period at about 240 stream-gaging stations; records of storage in many reservoirs; summary of peak discharges with comparative data for other floods at about 530 measurement points; tables showing crest stages along aggregate length of stream channel for 1,450 mi.; records of precipitation at about 745 places; records of ocean-wave height at about 230 locations along coast; and records of water level in 31 observation wells on Long Island. Report also includes basic information on hurricane and general weather conditions associated with flood analyses of rainfall and runoff and many other data pertinent to the floods.—*Ed.*

Natural Water Loss in Selected Drainage Basins. G. R. WILLIAMS *et al.* U. S. Geological Survey, Water Supply Paper No. 846 ('40). In study, water loss of drainage basin was taken as difference between average rainfall over basin and runoff. All data on an annual basis, for water years ending Sept. 30. Deep ground water movement in basins studied is relatively small. Required for study: 3-year rainfall and runoff record; rainfall stations well distributed over basin, mean altitude of stations approximating mean altitude of basin. Data obtained from geological survey water supply papers and weather bureau reports. Rainfall calculated by arithmetic mean of station records, where weighting would have little effect, and, in other cases, by Thiessen method. Rainfall adjusted for altitude in one mountainous basin; water loss corrected to land area basis, by estimating evaporation, for 3 watersheds having large water surfaces. Accuracy of results depend principally upon accuracy of rainfall data. Factors that cause variations in annual water loss from year to year in same basin: (1) annual rainfall, distribution among seasons, storms—all of major importance in arid and semi-arid regions; (2) sequence of wet and dry years; and (3) temp., wind, sunshine, humidity. Factors that cause variations between basins in same or similar regions: topography, soil, vegetal cover, rainfall, and temp. and other climatic factors. Water loss increases with mean annual temp. Map shows generalized lines of mean annual water loss and mean annual temp. over U. S. Graph shows relationship between mean annual water loss and temp. Data presented for following river basins: Merrimack, Connecticut, Delaware, Susquehanna, Savannah, Altamaha, Suwannee, Apalachicola, Choctawhatchee, Escambia, Mobile, Pearl, Ohio, St. Lawrence, Hudson Bay, Upper Mississippi, Missouri, Lower Mississippi, Western Gulf of Mexico. Min. mean annual water loss: Moreau R., S. D., ('31–'33), 14.1″. Max. mean annual water loss: East Fork of Tombigbee R., Miss. ('29–'33), 39.6.″—*R. Hazen.*

Better Evaporation Data Sought. ANON. Eng. News-Rec. **125:** 831 (Dec. 19, '40). U. S. Weather Bur. is experimenting on Morris Reservoir, Salt Lake City, with water-vapor transport method of determining evaporation. Method seeks to measure actual flow of vapor upward from evaporating surface. As water vapor is transported by atmospheric turbulence, rate of flow depends on vertical gradient of specific humidity and wind velocity (which determines

turbulence). Wind velocity is measured by anemometers at different levels above water surface; humidity is measured at same levels by electric psychrometers; and temp. and humidity at water surface by hygrothermographs. Floating raft carries equipment. Check measurements are made on 2 floating standard pans and 1 standard land pan at edge of reservoir. Reservoir, which is satisfactorily free from seepage loss, will be bypassed and evaporation measured by hook-gages placed in stillwells at various points. Preliminary data indicate that floating pan evaporation varies within range of 30–40% of that measured from land pans, and that computations of evaporation from vapor transport data will approach true values determined from changes in reservoir level.—*R. E. Thompson.*

Attributes of the Curve of Concentration. DAVID LLOYD. Wtr. & Wtr. Eng. (Br.) **42**: 346 (Oct. '40). Considers statistical problem in hydrology—comparison of skewed populations, in which pop. is defined as collection of data from one source. Pop. defined by mean, standard deviation, and by skewness in distribution. For example, in daily flows of a river, no. of pops. from tributary sources is unknown so analysis of variance is defeated. Paper deals with data forming heterogeneous pops. which are considerably skewed. Curve of concentration is a frequently-used device for exhibiting proportion of a pop. which is concentrated around a particular value of a variate. It is derived from accumulation of a first moment of the curve of frequency distribution of values of a characteristic or an integration of area under a rank diagram. Equation of curve in rank diagram generally intractable to integration by integral calculus; so evaluation of area of concentration has been subject to approximations. In '31, Lorenz published general solution of evaluation of area of concentration. Process involved in arriving at curve of concentration is that of two integrations proceeding from frequency curve. Several actual examples of river flow data were used, but to cover whole range of possible distributions, hypothetical pops. set up, having frequency distributions ranging from extreme negative skewness to extreme positive skewness. Observed frequency of sample exhibited was graduated by fitting a Pearson, Type III, equation, to two places of decimals,

$$y = 0.07\left(1 + \frac{x}{2.86}\right)^{-0.59} e^{-0.14x}$$

with origin at mean. Mean is 7.35 units of 100,000 gal.; total no. of observations 2,922.—*H. E. Babbitt.*

A Summary of Hydrologic Data, Bayou Duplantier Watershed, 1933–1939. GLEN N. COX. La. State Univ. and A. & M. College Bul. **32 N.S.: 7** (July '40). Total area of watershed, lying almost entirely within city limits of Baton Rouge, La., 0.808 sq.mi., of which 23% impervious (house tops, paved streets, concrete sidewalks and lake area of 64 acres, about $\frac{1}{8}$ of whole) and pervious remainder (golf course, park, lawns, vacant lots, gardens) mostly sodded with grass. Lake, created by damming bayou, artificial. Terrain alluvial; most of it does not readily absorb water. Geological history given. Runoff augmented from outside sources by small inflow of known amt. Control at lower end of lake, where surplus water drains off over concrete spillway. Continuous records of precipitation (pptn.), runoff and evapn. for small areas in South very rare, and opportunity one not to be neglected. Univ. of La. and U. S. Geol. Survey co-operated; investigations begun in Apr. '33 and still continue. Present report summarizes findings for first $6\frac{3}{4}$ yr. to end of '39, but must be borne in mind that true ave. conditions, as rule, require 40 or 50 yr. in which to establish themselves, and that period reviewed was one of deficient pptn. Mean annual rainfall at Baton Rouge based on 72-yr. record of weather bureau is 59.29″ (max. 87.99″ in '26; min. 37.78″ in '24). For 6 completed (calendar) yr. covered in study, mean was 51.19″ (max. 65.69″ in '34; min. 39.32″ in '38). Only 6 times in $6\frac{3}{4}$ yr. did daily rainfall reach total of 3″ or over, and 3.98″ was max. To provide picture of normal

expectancy, tabulation presented of all storms of 3″ or more rain per day during period under review in Baton Rouge and in 7 other typical and metereologically comparable cities of La., with respective dates and rainfall totals, from which pptn. expectancy for region for period under review synopsized as follows:

PERIOD	PPTN.
yr.	*in.*
50	12.25
25	11.80
15	10.50
10	8.60
5	6.00
3	4.80
2	4.10
1	3.25

Evident that max. of nearly twice 3.98″ could have been anticipated. From 5 to 7 standard U. S. Weather Bureau gages used, distributed over area, also recording gage, from which data on intensity and duration of pptn. obtained. Any storm during which, for any 5-min. interval, recorded pptn. was at rate of not less than 3″ per hr., considered to have excessive pptn. rate. During period reviewed, 42 such storms occurred—tabulated to show, respectively, date, max. 5-min. rainfall, and successive 10-min. pptns. throughout whole period of storm. From table, max. pptns. which occurred during periods of various durations summarized as follows:

PERIOD	PPTN.
min.	*in.*
5	0.68
10	1.10
30	1.53
60	2.36
90	2.46
120	2.59

These values greatly exceeded in Baton Rouge during storm in spring of '30, when approx. 4″ fell during 30-min. interval. Stage measured at lower end of lake by Stevens water level recorder located in gage house of latest type approved by U. S. Geol. Survey, adjacent to concrete spillway. Control measurements obtained in specially constructed current meter section about 40′ downstream from spillway; for very low stages, special methods devised. Rating curves thus obtained for conversion of stage readings to discharge in sec.-ft. Many and various obstacles presented themselves and were surmounted. Daily discharge given in one table; monthly and yearly summaries in another. Corrections made for evapn. from lake surface and for inflow from external sources. Yearly totals, in inches, for 6 calendar years, 1934–39, were:

YEAR	RAINFALL	RUNOFF
	in.	*in.*
1934	65.69	38.73
1935	55.85	33.25
1936	45.78	21.24
1937	50.55	22.77
1938	39.32	18.11
1939	49.96	28.43

Lake significant in 3 ways: (1) ranked as impermeable area; (2) comparatively large loss by evapn. took place from surface; and (3) reservoir action delayed discharge of runoff. 13 storms during period classed as causing flood flows and data closely scrutinized in each case to determine actual runoff. Results summarized in table giving, respectively, date, total pptn. in in., max. intensity of pptn. in in. per hr., total runoff in in., and max. rate of runoff, in sec.-ft. per sq.mi. For last item, greatest observed value 941, equal to 1.46″ per hr. evident that floods of greater proportions must be anticipated and allowed for in eng. constr. Of 48 storms classed as exceptional under one or other of 3 categories, only 2 appear under all 3 categories, while 2 appear only under first category and 2 others only under third, indicating different aspects of importance of pptn. problem for water engr. Amt. of evapn. from lake's surface being comparatively large and important item in obtaining hydrologic balance, necessary to deter-

mine it with accuracy. Extensive studies to this end fully reported, floating pan method proving satisfactory. Empirical formula developed and reliability established. In studies, fact, believed to be new, became apparent—that value of $T_w - T_a$, where T_w is temp. of water and T_a, that of air, has marked influence on rate of evapn., high (algebraical) values promoting it. Bayou Duplantier investigations being continued and recording gage now included in network under Fort Worth, Tex., office of U. S. Weather Bureau.—*Frank Hannan.*

Operation Experiences, Tygart Reservoir. Robert M. Morris and Thomas L. Reilly. Proc. A. S. C. E. **67:** 569 (Apr. '41). Some of problems involved in operation of large flood-control and water-supply project reported. Schedule of dual-purpose operation required for flood-control reservoir of limited capac. if it must augment seasonal low-water flow in streams below dam. Rate and quantity of low-water storage must be co-ordinated with flood-control operation to provide satisfactory results for both purposes. Gross capac. of Tygart Res. equivalent to 4.5″ of runoff from tributary drainage area. When low-water storage of 100,000 acre-ft. is in res., however, remaining flood-control capac. equivalent to only 2.9″ of runoff. This limited storage capac., therefore, presents problem of operation since outlet works cannot be closed arbitrarily at beginning of flood and opened when flood is past. True functions of res. of this type during general flood to delay rise of tributary flow only until streams to which it is affluent are falling below damage stage, and to keep magnitude of ultimate rise below this critical point. Since many of past floods of record in Upper Ohio R. Basin of double-peak and triple-peak variety, wherein one wave rises immediately on recession of another, importance of ending flood storage and beginning discharge at earliest possible moment obvious. Prediction of rainfall over area before rain has actually fallen represents ultimate hope of those engaged in flood-protection work. In simple terms, flood routing is analytical development and transition of flood wave—its inception from surface runoff in headwater areas of one basin, its subsequent movement downstream augmented by inflow from successive tributary streams and diminished by flattening of wave as it progresses downstream, and the effect of natural valley storage. One of primary purposes of construction of Tygart Dam to provide storage reservoir to supply adequate flow for navigation during low-water season. Since river extensively used as source of domestic and industrial water supply and at same time as disposal channel for sanitary and industrial wastes, any increase in seasonal low-water flow constitutes major benefit to industry and to general public in Monongahela Valley. Chemical analyses of reservoir water and of the river as recorded by various water works and industrial plants along course obtained continuously throughout '38 and '39. Total monetary benefits attributable to Tygart Dam for first 2 yr. of operation as follows: flood control, $2,818,000; navigation, $280,000; and water supply, $281,100. Period most probably does not represent ave. annual conditions since 3 of 5 largest floods of record on Tygart Basin occurred during time and Monongahela Basin experienced one of the worst droughts in its history.—*H. E. Babbitt.*

IMPOUNDING RESERVOIRS

Small Impounding Reservoirs for Rural Water Supplies. A. F. Meyer. Gas u. Wasserfach. (Ger.) **83:** 685 (Dec. 28, '40). Still problem to decide when expedient to build small reservoir for water supply. Cannot be denied that farmer just as much entitled to sufficient and safe supply as city dweller, yet small reservoirs can only be economical when they serve relatively large territory. Small installations require careful planning to get foolproof operation by relatively little-trained personnel they can afford. Small reservoirs also require very care-

ful study of dam structure, its location, and geological condition. Hydraulic conditions and especially problems of pollution and biological growth in water may be completely different from those encountered in large deep reservoirs.—*Max Suter.*

Bituminous Surfacing Treatment of Portion of the Water Supply Catchment at Narrogin, Western Australia. J. W. YOUNG. Jour. Inst. Engrs., Australia **13:** 52 (Feb. '41). For some years past, ways and means of providing artificial catchments for areas of light rainfall and small runoff investigated. At end of 4-yr. period, exptl. surface of ¼ acre at Narrogin found in excellent condition. Decided to undertake work of similar character on area of 50 acres. Soil in area light loam to sand. To secure finished bituminous surfaced catchment, following operations required: (1) clearing; (2) ploughing and harrowing; (3) stabilization of light soil with clay; (4) consolidation of soil by rolling under both dry and moist conditions; (5) application of fuel oil (0.5 gal. (Imp.) per sq.yd.); (6) provision of light impervious surface of emulsified bitumen and sand (0.4 gal. (Imp.) of emulsion per sq.yd., placed in two applications); and (7) provision of necessary drains to discharge water into reservoir. Ordinary commercial fuel oil used, with slow breaking casein emulsion of *Terolas* type, manufactured from bitumen of 180-200 penetration. Runoff from area of 2 acres arranged to pass through still box fitted with V-notch weir and recording gage, and pluviometer established in center of area. Observations show that, on swept surface of new work, water commences to run on surface when 2 points of rain have fallen.—*H. E. Babbitt.*

The Youghiogheny River Reservoir Project. F. HERBERT SNOW. News-Letter. **7:** 7: 12 (July '40). Project under construction by U. S. Army Engrs. for flood control, navigation, pollution abatement. Dam to be located on Youghiogheny R. between Confluence, Pa. and Friendville, Md. Drainage area 435 sq.mi. Total storage of 254,000 acre-ft. allocated as follows: in winter, permanent storage, 5,000; conservation, 99,000; flood storage, 150,000; in summer, permanent storage, 5,000; conservation 149,000; flood storage, 100,000. Peak flood of 112,000 cu.ft. per sec. reduced to 93,500 through res. Dam to be rolled earth fill; upstream slope 1 on 3½, downstream slope, 1 on 2, terminating in rock toe. Length of dam, 1,600′; max. height, 184′; 3,230,000 cu.yd. rolled fill; 300,000 cu.yd. rock fill. Spillway design capac. 128,000 cu.ft. per sec. Normal discharge through gate-controlled 18′ diam. tunnel. Total estimated cost of project, $9,000,000; annual charges, $383,000. Total annual benefits estimated at $1,209,000, as follows: flood control, $1,073,000; navigation, $34,000; pollution abatement, $102,000.—*R. Hazen.*

Measuring Reservoir Capacity From Twenty Thousand Feet. ANON. P. P. Eng. **44:** 11: 89 (Nov. '40). Aerial survey work has been extended by improved technique and equipment. Method had advantage of being relatively rapid and highly accurate. In particular example, entire operation of determining capac. of reservoir required but 3 weeks after location of control elevation points. Normal ground survey operations require period of six mo.—*T. E. Larson.*

The Safe Yield From Mundaring Reservoir. HUGH MACLEAN WILSON. J. Inst. Eng. (Australia) **12:** 2: 39 (Feb. '40). Res. designed to furnish 5 m.g.d. to Kalgoorlie mining industries and neighboring agricultural country. Situated on Helena R., with catchment area of 569 sq. mi., and capac. of 4,650 mil. gal. From 1897 to '39, ratio of runoff to rainfall varied from 0.2% to 11%. Statistical analysis of runoff made to determine safe yield and probability of res. shortage. With present capac., probability of failure under various drafts estimated as follows: 5 m.g.d., 0.5%; 6 m.g.d., 2.5%; 7 m.g.d., 7.4%.—*R. Hazen.*

Dike Reservoirs Solve Illinois Water Problems. ANON. Eng. News-Rec. **126:** 178 (Jan. 30, '41). Blandinsville, Ill., situated in region where suitable ground water is not available, will soon be supplied with water from nearby

creek. Water will be pumped from creek into reservoir, constructed by building dike on 4 sides of plot of ground, and then flow by gravity through 100-g.p.m. treatment plant. Creek has drainage area of 3.5 sq.mi. and res. will have capac. of 27 mil.gal., sufficient for 6 mo. consumption by population slightly under 1,000, plus evaporation loss, which will amount to about 10 mil.gal. per yr. Cost of improvement was about $15,000 less than cost of acquiring land and building impounding res. which offsets additional operating cost of having to pump water. 3 other villages in state have been supplied similarly and state san. engrs. believe that dike type res. will solve water supply problem in many Illinois towns where ground water is not available.—*R. E. Thompson.*

The Use of Benochlor-3 in Potable Water Supplies. M. M. Gibbons. W. W. & Sew. **87:** 231 (May '40). For recreational use, aquatic weeds need to be controlled in reservoirs in some cases. Paper describes application of herbicide to res. contributing to Rahway, N. J., supply. Application of Benochlor-3 imparted characteristic aromatic chem. odor to res. effluent, which persisted 12 days and was gone in 33 days. Odor is reduced by dilution with untreated water, by absorption by organic matter in water, by storage, or by aeration. In this case no objectionable results were found.—*H. E. Hudson, Jr.*

The Control of Large Water Vegetation. W. F. Hicks. Proc. 21st Tex. W. W. & Sewage Short School. (Feb. '39) p. 64. Author describes control methods used with American Lotus or Nelumbo Lutea. Control methods consist in cutting lilies approx. 12″ or 14″ under water before they bloom, and getting all of them removed from lake before they go to seed. Has developed a mowing machine constructed of a regular horse-drawn mower mounted on a barge and driven by stationary gas engine. Mower so arranged to place mowing sickle at depth of 12″ to 14″. By use of method, in 3 years, a lake which was almost solid with lilies, almost completely cleaned. To maintain control takes very little work every year.—*P. H. E. A.*

Aquatic Plants in Meander Lake. W. I. V. Arnum. Growths of *Naias flexilis* have spread from 2 small ponds into bay of Meander Lake and thence along whole shore of lake. Treatment with 50 lb. copper sulfate per mil.gal. did not kill plant. Found that spraying with "Benoclor 3" would destroy weeds, but taste and odors were caused. Method might have been used when growth first began, but treatment of entire shore would have caused too great risk of tastes and odors.—*W. P. R.*

ALGAE CONTROL

An Algae "Black-out". Wm. T. Bailey. W. W. & Sew. **87:** 380 (Aug. '40). Chlorination for prevention of microscopic growths in coagulation basins at Council Bluffs, Ia., not entirely satisfactory, nor was use of copper sulfate. Application of powdered activated carbon to prevent sunlight penetration proved highly successful. Procedures and operating data are given.—*H. E. Hudson, Jr.*

Ocean Pasturage in California Waters. W. E. Allen. Sci. Monthly. **52:** 261 (Mar. '41). Studies in recent years have shown that variations in phytoplankton distr. with seasons, depths, localities and latitudes are directly related to movements of air and water masses, and that variations influence and are influenced by turbidity, density, temp., light, dissolved substances, co-existent organisms and indefinite numbers of other chemical, physical and biological characteristics of sea water. Generally recognized that phytoplankton constitutes basic food (directly or indirectly) for fishes and at same time draws much of its own sustenance from them. Scripps Inst. of Oceanography of Univ. of Calif. has studied phytoplankton of Pacific Ocean for many years. Little is yet known of

contribution of dissolved oxygen to ocean water by phytoplankton or distributional relationships of other elements such as carbon, phosphorus and nitrogen, or direct or indirect effects of runoff from land. Phytoplankton may sometimes become so abundant as to injure seriously many surrounding animals, possibly by mere crowding, possibly by clogging of gills, possibly by direct poisoning in some cases.—*Selma Gottlieb.*

Plankton in the Water Supply. FLORENCE E. MEIER. Smithsonian Rept. ('39) p. 393. Short history of microscopic exam. of water given and plankton groups listed. Physicochemical factors influencing plankton production briefly enumerated. Plankton stated to have no. of effects on water supplies—causes tastes and odors, turbidity, and stains on porcelain fixtures; has interfered with cleaning of clothes in laundries, with proper dyeing, and with proper development in photography. Swimming pools have been fouled and swimmer's itch was caused by Cercariae. Blocking of filter at Washington, D. C., filter plant shown to have been caused by plankton diatoms. Sources, storage, filtration, and treatment of water in relation to plankton discussed. Useful table of troublesome organisms together with characteristic odors and amts. of copper sulfate and chlorine necessary for treatment appended. [Amts. of these 2 chemicals now subject to revision, because of effect of water composition on $CuSO_4$, and developments in break-point chlorination.]—*P. H. E. A.*

Limnological Studies of Western Lake Erie. *I. Plankton and Certain Physical-Chemical Data of the Bass Islands Region. From Sept., 1938, to Nov., 1939,* DAVID C. CHANDLER. Ohio J. Sci. **40:** 291 ('40). Year-round limnological data based on weekly collections presented. Emphasis placed on seasonal variation of centrifuged phytoplankton, net zoöplankton, and certain phys. and chem. conditions characteristic of region. Routine chem. analyses made at following depths: surface, 5 m., and 9 m. D.O. varied from 5.0 p.p.m. in Aug. and Sept. to 12.9 p.p.m., in Mar., under ice-cover. Variation from surface to bottom did not exceed 2 p.p.m. and often it was nearly uniform. H-ion concentration varied from pH 7.5 to 8.4, with max. occurring from July to Oct. and min. from Nov. to Apr. No marked variation in vertical distr. of pH detected despite temporary thermoclines. Free carbon dioxide varied from 0.0 to 2.9 p.p.m. from Sept. '38, to Nov. '39. In general, free carbon dioxide present from Dec. to May, and nearly absent rest of year. Vertical distr. almost uniform from surface to bottom for given date, regardless of season. Alky. of water in region due almost entirely to bicarbonates, which varied from 96.9 p.p.m. in Sept. '38, to 82.0 p.p.m. in Mar. '39. Vertical distr. of bicarbonates varied as much as 4 p.p.m. from surface to bottom on given date. Carbonates absent from Sept. '38, to late May '39. When present, carbonates varied from min. of 0.5 p.p.m. in June to max. of 4.4 p.p.m. in Sept. No indications that chem. factors mentioned above have limiting effect on plankton production.—*C. A.*

The Chemical Composition of Plankton. III. A. P. VINOGRADOV. Trav. Lab. Biogéochim. Acad. Sci. (U.S.S.R.) **5:** 47 ('39). Dried samples of various species of *Diatomaceae, Peridineae, Cyanophyceae, Copepoda, Branchiopoda, and Amphipoda* were analyzed and their caloricities determined. Crustacean plankton gave highest caloric value and was richest in phosphorus. *Amphipoda* were highest and *Copepoda* lowest in calcium. Silicon content was very low and only traces of titanium and zirconium were found. *Cyanophyceae* were rich in potassium and nitrogen. Diatomic plankton was rich in silicon, manganese, iodine, and arsenic, and poorest in nitrogen. 43 refs.—*C. A.*

Study of Regeneration of Nitrogen and Phosphorus Compounds in the Course of Decomposition of Dead Plankton. B. A. SKOPINTSEV AND E. S. BRUK. Compt. Rend. Acad. Sci. (U.S.S.R.) **26:** 807 ('40) (*In English*). Study of plankton taken from water basin near Moscow, in which prevailing form was blue-green alga *Mi-*

crocystis aeruginosa, shows that processes of decomposition similar to phenomena taking place during mineralization of organic matter in sewage waters. Calculation of constant of B.O.D. (K_D) and that of ammonification (K_A) gave following values: at 16°, $K_D = 0.082$ and $K_A = 0.108$; at 6°, values were 0.035 and 0.061, respectively. Ammonification percentage, computed by means of constants, for 10 days, was 91% at 16° and 75% at 6°. Decrease in organic phosphorus and increase in phosphate indicate that 60–70% of plankton became mineralized within 54 days, while increase in mineral nitrogen indicates 83% mineralization. This attained in 17–20 days. Determination of degree of breakdown of chlorophyll pigment of plankton shows that, within 53 days at temps. of 6° and 16°, 52% and 82% of pigment, respectively, destroyed. —*C. A.*

Influence of Moonlight on the Photosynthesis in Fresh Water Algae. V. S. IVLEV AND M. I. MUKHAREVSKAYA. Compt. Rend. Acad. Sci. (U.S.S.R.) **27:** 71 ('40) (*In English*). Photosynthesis by algae in Volga R. was measured in full moonlight. Carbon dioxide absorption was 7.6% greater in lighted than in darkened jars. Because of large variations among individual determinations, figure is not mathematically significant. —*C. A.*

The Blooming of the Uchinskiĭ Reservoir. K. A. GUSEVA. Bull. Soc. Naturalistes Moscou, Sect. Biol. **48:** 4: 30 ('39). Max. mass development of plankton organisms ("blooming") in water coincides with max. content of iron. High manganese content during second yr. after flooding had toxic effect on plankton. *Anabaena* requires more iron than *Aphanizomenon* for its max. development. *Asterionella* is intermediate. *Coelosphaerium* requires ammonium salts (0.8 p.p.m. nitrogen is optimal), and very little iron. *Oscillatoria* also requires nitrogen (0.2 p.p.m.) rather than phosphorus or iron.—*C. A.*

Larvae and Crustacea. ROSS A. THUMA. W. W. & Sew. **87:** 214 (May '40). Strange stagnant odor, attributed to Phantom mosquito larvae appeared at St. Paul, Minn., filtration plant. D.O. was reduced, filters suffered from cementation, but filtered water quality seemed satisfactory. Larvae of other flies have also appeared at times. *Daphnia* and *Cyclops* have also been troublesome through reducing filter runs. Lime treatment has proved very helpful, killing troublemakers and lightening filter load. Seeding water with small fish also very helpful. Pre-chlorination unsatisfactory since it produces chloro-substitution products of great offensiveness. Biologic control best.—*H. E. Hudson, Jr.*

HEALTH AND HYGIENE

Domestic Water and Dental Caries. *I. A Dental Caries Study, Including* L. acidophilus *Estimations, of a Population Severely Affected by Mottled Enamel and Which for the Past 12 Years Has Used a Fluoride-Free Water.* H. TRENDLEY DEAN, PHILIP JAY, FRANCIS A. ARNOLD, JR. AND ELIAS ELVOVE. Pub. Health Rpts. **56:** 365 (Feb. 28, '41). Epidemiological evidence points to inverse relationship between endemic dental fluorosis and dental caries. Whether inhibitory agent operates locally, systemically, structurally or compositionally, is not clear. Exams. made of 82 Bauxite, Ark. children from 6 to 15 yr. old; 42 born prior to, 40 born after water supply was changed from deep-well water containing 13 to 14 p.p.m. fluoride (F), to Saline R. filtered effluent, F-free. Comparative exams. also made on 50 Bauxite and 45 Benton, Ark., high school pupils using same F-free water all their lives. *L. acidophilus* counts made on both groups. Authors stress 2 points: (1) Older Bauxite group, all showing moderate to severe endemic dental fluorosis, disclosed markedly less dental caries than comparable Benton group, free of mottled enamel. (2) Cumulative increase in amount of dental caries experience with increasing years exposure to

risk did not hold in Bauxite school pop. studied. Reversal in trend of this epidemiological constant suggests noticeable physiological influence which operated in this pop. and presumably was associated with change in communal water supply. This limited immunity from dental caries is seemingly not dependent upon presence of macroscopic mottled enamel, because children born within several years of change in water supply, and almost free of mottled enamel, likewise disclosed low dental caries experience. Youngest age Bauxite group, those farthest removed in time from influence of "old" high fluoride water, shows highest dental caries experience in spite of their exposure to caries risk for shortest time. *L. acidophilus* counts apparently reflect difference in caries activity in several groups studied, a result seemingly consistent with clinical findings. Teeth moderately to severely affected with mottled enamel showed no tendency to rampant dental caries, even though exposed to a F-free water for past 12 yr. 7 tables, 27 refs. *II. A Study of 2,832 White Children, Aged 12-14 Years, of 8 Suburban Chicago Communities, Including* L. acidophilus *Studies of 1,761 Children.* H. Trendley Dean, Francis A. Arnold, Jr. and Elias Elvove. *Ibid.* **56:** 761 (Apr. 11, '41). Purpose of study to determine how low a fluoride (F) conc. in public water supply would be found associated with relatively low dental caries rates; and to check possible rôle of other constituents of water not yet ruled out epidemiologically. Sampling and clinical exam. methods described indicate thoroughness and care with which study conducted. Authors found neg. correlation between F conc. of public water supply and dental caries experience of children continuously exposed to such waters. Study of 8 suburban Chicago communities discloses marked differences in amt. of dental caries. Experience rates in Elmhurst, Maywood, Aurora, and Joliet, whose public water supplies contain 1.8, 1.2, 1.2 and 1.3 p.p.m. F, respectively, were 252, 258, 281, and 323. At Evanston, Oak Park, and Waukegan, using F-free water, rates were 673, 722, and 810. Using proximal surfaces of 4 superior permanent incisors as basis of measurement, there was 14.3 times as much of this type of dental caries in 1,008 children from Evanston, Oak Park, and Waukegan as in 1,421 from Elmhurst, Maywood, Aurora, and Joliet. Differences in *L. acidophilus* counts in saliva corresponded to differences in dental caries experience in groups of communities studied. Considering relative homogeneity of these urban pops. and sampling method followed, difficult, epidemiologically, to ascribe these observed differences to any cause other than common water supply. Dental caries inhibitory factor, presumably F, operative at such low concentrations (e.g., 1.2 p.p.m. F in Aurora) that mottled enamel, as esthetic problem, not encountered. 15 tables, 10 figs., 9 refs.—*Ralph E. Noble.*

Bone Changes in Endemic Fluorosis. H. A. Mascheroni, J. M. Muñoz and C. Reussi. Rev. Soc. Argentina Biol. **15:** 417 ('39). Osteopetrosis observed in young woman who had lived all her life in dist. in which fluorine occurs in drinking waters in high concs. Post-mortem exam. confirmed radiographic diagnosis. Fluorine content of bone ash 0.975%. —*C. A.*

The Significance of Fluorine Traces in Natural Waters and a Proposed Method to Effect Their Removal. P. K. v. d. Merwe. Onderstepoort J. Vet. Sci & Animal Indus. (S. Afr.) **14:** 1,2: 335, 57 (Jan., Apr. '40). Article opens with interesting account of fluorosis and symptoms. Detailed description of process by which conc. of fluorides in South African waters can be reduced to level safe for human consumption. Agent studied derived from commercial superphosphate. One kg. of double superphosphate can, by author's concentrate method of removal, get rid of 9–10 grams fluorine from solution. Heat accelerates reaction, but prolonged cold agitation will in time attain same degree of removal, showing that process is time reaction. Fluorine removal accompanied by improvement in general character of water treated; total solids reduced and metals form insoluble

secondary and tertiary phosphates. Sodium, calcium and silico-fluorides all reduced, chemical combination of fluorine being apparently unimportant. Treated waters found to contain less than 1 p.p.m. fluorine.—*B. H.*

The Removal of Fluorine From the Drinking Water of Children. P. K. v. d. Merwe. Farming (S. Afr.) **15:** 360 ('40). In many rural parts of South Africa, domestic water supplies contain considerable conc. of dissolved fluorides. Recommended that max. permissible conc. of fluorine in drinking water of children under conditions prevailing be approx. 0.8 p.p.m. Mottled enamel described as primary water-borne disease, caused by fluorine dissolved in water, fluorine content of food playing no significant part, and is compared with Darmous type of poisoning encountered in "phosphate zones" of North Africa. Later a secondary water-borne disease caused by ingestion of phosphate dust containing fluorine. Children susceptible to dental fluorosis up to age of 8; drinking water containing toxic concentrations of fluorine should therefore be treated before being supplied to children up to this age. Possible to do this by dilution of water with rain or flood water, but most practicable method is by removal of fluorides by chemical methods, of which filtration through active phosphate has been most developed. Constant supervision by chemist required, and method more practicable for use in South Africa whereby water mixed with active phosphate. May be done on large scale by adding about 2 gal. of a highly concentrated aqueous solution of superphosphate to 1,000 gal. of water, stirring, and gradually adding powdered slaked lime to precipitate phosphate. Excess lime can be precipitated by forcing carbon dioxide through water. Method of treatment for small-scale use described. Active phosphate prepared from solution of superphosphate freed from sulfates and fluorides by settlement. Lime then added gradually, in proportions of 1 lb. of lime for every 3 gal. of solution, until all phosphate has been precipitated (endpoint indicated by phenolphthalein). Precipitate washed free from excess lime and dried. About 1 oz. of phosphate added to 3 gal. of water to be treated, mixture heated to about 70°C., and stirred for some time. Mixture then allowed to flow through washed sand, which removes particles of phosphate. Water treated thus will contain about 0.05 to 0.3 p.p.m. fluorine.—*W. P. R.*

Fluorides in Food and Drinking Water —A Comparison of Effects of Water-Ingested *vs.* Food-Ingested Sodium Fluoride. E. J. McClure. Nat. Inst. Health Bul. No. 172 (1939). Effects produced on young growing rats by fluorine administered in drinking water or in food in quantities equivalent to 22.6, 45.2, and 90.4 p.p.m. of their drinking water, were investigated. No noticeable difference could be detected between effects of fluorine ingested in food as compared with that ingested in drinking water. About 180 p.p.m. fluorine in form of sodium fluoride in drinking water caused acute toxic effects. In young growing rats, ave. total retention of fluorine from sodium fluoride may equal 30–40% of intake. Most of fluorine retained is deposited in bones and teeth. Degree of hypoplasia of teeth is directly correlated with quantity of fluorine present. In young rats 22.6 p.p.m. fluorine appears to stimulate appetite and drinking of water and perhaps increases daily body gain; 45 p.p.m. fluorine causes decrease in rate of body gain. Sodium fluoride in quantities equivalent to 22.6—600 p.p.m. fluorine increases ash content of bones. Max. amount of fluorine which may be present in whole tooth without affecting appearance of tooth enamel is 0.03–0.04%. Accumulation of fluorine in bones of adults may be expected in districts where mottled enamel is endemic. Further study is required concerning quantity of fluorine in foods, toxicity of natural fluorides as compared with inorganic fluorides, factors involved in the absorption and metabolism of fluorides, and effect of fluorine on bone tissue.—*C. A.*

Fluorine Content of Alberta Waters. A Cause of Mottled Teeth. Osman James Walker. Can. Engr. **78:** 11: 16 (Nov. '40). During calcifying period,

fluorine in excess of 0.9 p.p.m. in water supply interferes with metabolism in such a way that fluorine replaces carbonates and phosphates in tooth enamel, giving rise to unattractive appearance. White opaque spots occur when fluorine content is 0.9–1.5 p.p.m., and yellow, brown or black spots or bands when content increases to 2.5, 5 or 8 p.p.m. Bones are affected when fluorine is present in amounts of 12 p.p.m. or more. Report of mottling from area in Alberta led to survey of water supplies of whole province. Over 1,000 samples were examined. Tabulated summary of results is given. In general, water from deep wells (90′ or more) tends to have higher fluorine content than surface water and water from shallow wells. In several instances, however, reverse was found to be true. Highest content found was 4.5 p.p.m. High fluorine waters had pH of about 9 and often were high in sodium bicarbonate. Data on mottling is not complete but it is estimated that over 1,000 citizens are so affected. In as many mottling cases as possible, water supplies were examined and invariably fluorine content was above threshold value, 0.9 p.p.m., extent of mottling varying with fluorine content. Only exception was mild mottling among residents who use water from creek at Cardston, which has low fluorine content. In some cases, high fluorine contents were found in districts free of mottling, e.g., repeated analyses of water from school well at Three Hills show about 3 p.p.m. fluorine but no mottling has been reported.—*R. E. Thompson.*

The Removal of Fluorine From Alberta Waters. O. J. WALKER, G. R. FINLAY AND W. E. HARRIS. Canadian J. Res. **17**: B: 308 ('39). Discusses methods for removal of fluorine from water and describes investigation carried out to find suitable materials for removing fluorine. Edmonton, Alberta, tap water, derived from North Saskatchewan R., to which known quantity of fluorine had been added, used in the tests. Many materials tested did not remove fluorine, but fluorine content of water could be reduced to below 1 p.p.m. by treatment with magnesium oxide, activated alumina, tricalcium phosphate, hydrated alumina after treatment by heat, mixture of alumina and calcium carbonate, and freshly prepared aluminum phosphate. Best results obtained with aluminum oxide dried at 81°C., and with aluminum phosphate. In some expts. water filtered through material, but in most, material stirred with known quantity of water and allowed to stand overnight. Water then drawn off and analyzed and fresh portion treated in same manner. Process was repeated until material exhausted. Results of expts. shown in tables and graphs. Commercial units containing tricalcium phosphate (Defluorite B) installed at 3 towns in Alberta where water supplies contained fluorine. Operation satisfactory.—*P. H. E. A.*

Chronic Endemic Fluorosis in Northern India. C. D. MARSHALL DAY. Br. Dental J. (Br.) **68**: 409 ('40). Numerous endemic areas exist throughout Northern India, fluorine concentration in well water varying from 1.2 to 6.4 p.p.m. Enamel mottling is almost universal in both young and adult residents, while incidence of caries is low. Deciduous teeth of children between 5 and 7 yr. were affected: this indicates that placenta is permeable to fluorine and that fluorine is probably present in mothers milk.—*C. A.*

Studies in Chronic Selenosis. M. I. SMITH, R. D. LILLIE, E. F. STOHLMAN AND B. B. WESTFALL. Natl. Inst. of Health, Bul. 174. (Aug. '40). Selenium (S) found in cereal grains in South Dakota. Pathologic conditions in domestic ungulates, known as "alkali" disease, has occurred in S. D. and adjacent states. Has been reproduced in pigs, experimentally, by feeding S-bearing corn. Condition in ungulates characterized by hoof deformities, some loss of hair, loss of wt., serous effusions and inflammation and swelling of joints. Studies of S intoxication in man show that appreciable amts. may be absorbed through ingestion of S-bearing food stuffs including milk, eggs and meats from animals subsisting on seleniferous grain and vegetation. Urinary analyses from individuals in S-endemic regions average 20 to 50 micrograms per cent S., while some show

200. Expts. made with lab. animals to determine probable margin of safety in man. *I. Chronic Toxicity of Naturally Occurring Food Selenium:* Data show systemic effects and morphologic changes in tissues of animals fed graded doses of naturally occurring food S over periods up to about 1 yr. Results indicated food S less toxic than inorganic sodium selenite or selenate. Doses in excess of 1 mg. per kg. per day dangerously toxic. Doses up to 0.5 mg. per kg. per day may be tolerated without causing serious symptoms or pronounced tissue damage, though doses as small as 0.2 may cause minor symptoms, such as derangement of gastric function and some impairment of liver function. 6 tables, 4 cuts, 18 refs. *II. Gastric Acidity in Chronic Selenium Poisoning:* Free and total gastric acidity in response to alcohol or histamine studied in series of rats and cats chronically poisoned with inorganic or naturally occurring food S. Marked or constant diminution in free or total gastric acidity not essential feature in chronic S poisoning. 4 tables, 5 refs. *III. Liver Function and Bile Pigments in Experimental Chronic Selenium Poisoning:* Study of bile pigments and liver function tests in series of rabbits and cats chronically poisoned by continued voluntary ingestion of small doses of food S showed liver undergoes structural changes, giving mild chronic interstitial hepatitis, occasionally portal cirrhosis. No bilirubinemia found. Urinary urobilinogen not significantly increased over control animals. Abnormal retention of intravenously injected bilirubin and of rose bengal found in most chronically poisoned animals. No abnormal retention of intravenously injected bromsulphalein demonstrated. Increased retention of bilirubin usually paralleled rose bengal. Incidence and degree of abnormal retention of latter usually higher. Decreased elimination of hippuric acid following standard dose of intravenously injected sodium benzoate found in many animals compared with normal controls. Liver efficiency, measured in terms of reduced hippuric-acid output, usually paralleled that when measured in terms of increased retention of rose bengal. Latter test was, however, more often positive and consistent with histologic findings. Author concluded that bilirubin, hippuric-acid, and rose bengal tests probably measure same or similar liver functions, latter test being most sensitive and specific in discerning liver dysfunction in chronic S intoxication. 10 tables, 6 figs., 40 refs. *IV. Selenium in the Hair as an Index of Extent of Its Deposition in Tissues in Chronic Poisoning:* Analysis of hair of animals in chronic poisoning with food S shows that concentration of S on basis of dry wt. usually greater than in liver or kidney calculated on wet wt. basis. Comparison of urinary and blood S in animals on constant food S intake indicates conc. ratio usually from 1 to 2. After discontinuing ingestion of S for some time, conc. ratio reduced to less than 1, blood conc. of S being higher than that of urine. Method for S analysis in biological material described in detail. 1 table, 5 refs.—*Ralph E. Noble.*

Typhoid Fever Occurring in Immunized Persons. B. MALBIN. J. Am. Med. Assn. **115:** 33 ('40). Water-borne epidemic of typhoid fever broke out in military hospital in Spain [presumably during civil war] which contained approx. 1,700 patients and 200 staff, 90% of whom had been immunized 3 to 12 mo. previously. Altogether, 147 cases of proved typhoid, but probably no. of mild undiagnosed forms of disease, incidence among non-immunized being approx. 25%, and 6% among immunized. Mortality for non-immunized group 10.2% and for immunized group 4%. Only 14.3% of immunized showed classical typhoid course. Constant clinical characteristics in order of frequency were bradycardia, splenomegaly, and leucopenia. In treatment prostigmin valuable remedy for tympanites.—*B. H.*

A Water-Borne Epidemic of Typhoid Fever. S. R. LOPEZ. Puerto Rico Health Bul. **4:** 1 ('40). Of 3 typhoid epidemics in Puerto Rico in last 3 yr., last occurred at Ponce; pop. 64,254. Typhoid has been endemic with cases dropping to 44 in '37 after chlorination of water supply. In July-Aug., '38, heavy

rains washed clean banks, etc., of Portuguese River, at that time the main source of water supply. Cases numbered 198 with 26 deaths; 146 cases were white, 44 colored, and 8 unclassified. Simultaneous uniform outbreak about city incriminated public water supply and analysis showed high contamination previous to epidemic. Several thousand laborers living in adjacent sugar-cane section, but with independent water supply did not produce a single case. Epidemiological studies later revealed 48 persons having had typhoid previously, lived along river bank and had no latrines, or very poor ones. None of positive typhoid histories gave positive fecal exams. Actual source of contamination never discovered, but Puerto Rico surface waters known to be heavily contaminated due to use of streams for bathing, refuse and excreta disposal, clothes washing, etc.—*P. H. E. A.*

An Outbreak of Typhoid Fever Associated With a Trailer Camp. P. A. LEMBCKE AND P. J. RAFLE. N. Y. State J. of Med. **40:** 18: 1371 (Sept. 15, '40). Record of 18 cases of typhoid fever and 12 additional cases of gastro-enteritis which occurred among persons in trailer camp during period Aug. 2 to 9, '38. Of typhoid patients 3 died and 2 became carriers. Source of infection found to be a well, situated in fissured limestone and subject to pollution by adjacent cesspools and privies. Possibility of wide spread of disease contracted in trailer camp shown by fact that permanent homes of typhoid cases were in 7 different states, while many of patients visited several other trailer camps during incubation period and early stage of disease.—*B. H.*

The 1927 Typhoid Epidemic at Montreal. H. A. HARDING. J. Bact. **39:** 72 ('40). In typhoid epidemic at Montreal in '27, 2 distinct outbreaks. Magnitude of epidemic implied long-continued massive infection. Investigation of possible causes of outbreak led to conclusion that infection caused by contamination of water supply through cross-connections with pipes leading from Lachine Canal; interval between two outbreaks coincided with period when canal was empty. —*W. P. R.*

Observations on Fecal Examinations in Poliomyelitis. JAMES D. TRASK AND JOHN R. PAUL. Am. J. Pub. Health. **31:** 239 (Mar. '41). Following discovery of virus of poliomyelitis (infantile paralysis) in material from human intestine in '12 and '15, little was done until '37 when additional tests made for fecal exam. and technique improved and simplified. Virus is active and stable in stools; appears in abortive (common) as well as in paralytic poliomyelitis (classical) forms. Convalescent and healthy carriers have been described and presence of virus demonstrated in sewage. Virus apparently more persistent in intestinal tract than in nose, largest proportion of positive tests from nose being found in first 48 hr. of disease; virus, however, may be found in stools for days and weeks (in one case for 100 or more days). Poliomyelitic virus found in sewage in 2 urban epidemics in '39. Indicates great natural source of virus exists in polluted waterways to which many forms of life besides man are exposed. Among experimental methods of transmitting disease to monkeys is through gastro-intestinal tract—raises question whether poliomyelitis may be water-borne. Possible importance of contaminated water rests on intestinal features of disease; its summer prevalence; and its production by feeding experimentally contaminated food. Considered unlikely, however, that epidemics are water-borne, because distribution of cases generally at variance with idea, disease usually most prevalent in rural sections with no common water supply. Authors state: ". . . we must conclude that most epidemics are not water-borne *in the usual enteric sense.* However, polluted water may be important in some other way as yet undisclosed." Epidemics often linked to river valleys. Chlorine dosages as high as 0.5 p.p.m. with exposures of 1 hr. not effective in destroying virus; authors' own expts., however, have indicated 2 strains —one highly susceptible, other quite resistant, to Cl. At present not evident that presence of poliomyelitic virus in

sewage is direct or even indirect link in chain which usually or even occasionally leads this infectious agent from one person to another. Until more information available deemed unwise for health officer to introduce new methods of control.—*Martin E. Flentje.*

The Virus of Poliomyelitis in Stools and Sewage. J. R. PAUL, AND J. D. TRASK. J. Am. Med. Assn. **116:** 493 (Feb 8, '41). Newer methods of testing human feces and sewage for presence of virus of poliomyelitis are described, and instances cited of value of such methods in detecting virus throughout infected community during epidemics. Poliomyelitis is probably generally transmitted from person to person by number of different channels, particularly through close and intimate contact between persons. Theoretically, "there may also be a variety of other channels in which contaminated food, milk and water, or conceivably insects, mammals or birds, play a part." Virus of poliomyelitis has never been isolated from "running water," but tests herein reported show that it has repeatedly been isolated from "running" sewage. Not evident from this last finding whether its presence in sewage is direct or even indirect link in chain which leads this potentially infectious agent from one patient to another in the disease. Observations merely call attention to fact that virus is there during epidemics. [Data presented in article suggest possibility of spread of poliomyelitis infection through water used for drinking or bathing].—*J. H. O'Neill.*

Observations on Non-Industrial Lead Poisoning. J. N. M. CHALMERS. Glasgow Med. J. (Br.) **16:** 6: 199 (Dec. '40). Fatal case of plumbism presenting mainly cerebral symptoms and signs reported. Patient was farmer's wife, whose earlier health had been good. Stated that she had never worked amongst lead and never taken any medicine or pills other than those prescribed by her doctor. Found that water supply to farm came from a spring and was conveyed to a collecting tank through lead pipe ¾ mi. long. Samples from cold tap in farm kitchen showed ave. lead content of over 6 p.p.m. No evidence of lead in water from collecting tank, but when tested for plumbosolvency in standard lead pipes, gave ave. of over 30 p.p.m. lead. Pipe laid for about 8 yr. but family resided there for only 2 yr. Thus, source of contamination proved to be service pipe, which has been replaced by bituminous-lined iron pipe. Pipes of similar construction installed in house. Others in the family tested for evidence of lead-poisoning; farmer himself showed some signs and symptoms but two children free from evidence of poisoning. Treatment by high calcium diet described and author of opinion "that a supply consistently delivering water containing 0.1 p.p.m. or more of lead should be regarded with suspicion and efforts should be made to lower the value." Question of non-industrial lead-poisoning and behavior of lead in body are reviewed. 43 refs.—*P. H. E. A.*

Soil and Fresh-Water Iodine Content in Ireland in Relation to Endemic-Goiter Incidence. J. C. SHEE. Sci. Proc. Roy. Dublin Soc. (Ireland) **22:** 307 ('40). Surveys of incidence of goiter among school children and determinations of iodine content of water and soil were made in several districts. Trevorrow and Fashena's modification of Leipert's technique was employed for iodine determination. Substance to be analyzed is subjected to chromosulfuric acid digestion, converting all iodine present to iodic acid. Acetic acid and other volatile substances formed are driven off by heating to 180°C. After cooling, a reducing agent is added to digest; flask is attached to closed glass suction system; and liberated iodine is distilled into a potassium hydroxide trap and estimated by Winkler's titrimetric principle. Investigations demonstrated that no correlation exists between fresh-iodine content and goiter distribution in Ireland. Iodine content of water does not necessarily reflect iodine content of soil through which it flows. Usually, soil will contain a thousand times as much iodine by weight as water flowing through it. Factors, such as texture,

pH, chemical constitution, and amount of organic matter present, may influence solubility of soil iodine. As rule, acid soil tends to hold iodine, and alkaline soil loses it by leaching. Soil analyses showed definite negative correlation between goiter incidence and soil iodine content.—*R. E. Thompson.*

Principal Causes of Death in Mexico. MIGUEL E. BUSTAMANTE AND ALVARO ALDAMA C. Rev. Inst. Salub. y Enferm. Tropicales. **1:** 205 (Sept. '40). Mortality record for '31–'37 in Mexico shows that among 31 leading causes of death, first place is held by intestinal disturbances, classified under diarrhea and enteritis, probably water-borne. Pneumonia and malaria take second and third places, while fourth and fifth places are held by violent deaths (excluding suicide) and diseases of nervous system. Whooping cough, measles, bronchitis and amebic and bacillary dysenteries are not very high in scale, but are important for high number of children's deaths they cause. Diseases of heart, of genito-urinary system, nephritis, nutritional disturbances, and cancer are increasing, while smallpox is definitely on downward trend. Tuberculosis, although decreasing slowly, is, nevertheless, quite high. Of deaths occurring in '37, 23.64% were children under 1 yr., 17.88% those between 1 and 2 yr. and 6.35% those between 3 and 4 yr. Data presented for country at large, are starting point for analysis by states of relative importance of leading causes of death.—*J. M. Sanchis.*

Criticism of the Methods for the Hygienic Examination of Drinking Water on the Basis of a Large Number of Analyses in Schleswig-Holstein. H. THIELE AND M. PEHRS. Arch. Hyg. (Ger.) **121:** 143 ('38). Authors show that presence of many of substances regarded as indication of pollution in water, may be due to other causes, and it is necessary to examine geology of district when making hygienic exam. of water supplies. Ammonia may be formed from nitrites or nitrates in water containing iron or flowing in iron pipes, from swampy soils, by nitrogen fixation, from artificial fertilizers, and from breakdown of plant and animal proteins, as well as from excreta of animals. Nitrites may be formed when iron or manganese is present in water from swampy soils, by nitrification of ammonia or denitrification of nitrate, from action of ultra-violet rays, from rain, from blasting, from freshly cemented well tubes, or from metabolism of some pathogenic bacteria. Nitrates occur in nearly all soils. May be formed from ammonia or nitrites by action of bacteria, by nitrogen-fixing bacteria, from biological purification of sewage, and from animal wastes. Presence of phosphates may be due to solution of phosphate minerals, to artificial fertilizers, to secretions of certain bacteria, or to animal wastes. Organic material may be derived from wooden pipes or well walls, from peaty soils, or from decomposition of plant and animal matter. Chlorides may be derived from deposits of mineral salt, from sea water, from factories, or from sewage. Bacteria reach ground water through fissures in the ground, by saturation of soil with bacteria, or by direct pollution of well water. Occurrence of such pollution in waters of Schleswig-Holstein discussed.—*W. P. R.*

Biennial Report, Tennessee Department of Public Health, 1937–39. Cumulative results of years of effort in health education and protection becoming apparent. During period typhoid and diphtheria reached lowest levels in history of state (1,243 and 1,615 cases respectively). Reports of various divisions given in some detail, including report of Div. of San. Eng. with eng. personnel of 6. Total of 4,737 visits made, 1,052 to public water supplies, 1,253 for industrial wastes and stream sanitation, and 96 for chem. study of water supplies. State has 195 public water supply systems serving 207 communities and 1,043,215 of state's 2,616,656 ('30) pop., 39.9%. 174 systems classified as of "good" sanitary quality, 19, "doubtful," and 14, "bad," percentage of pop. affected being respectively—95.0%, 3.5%, and 0.6%. Main sources of supply are: wells (98), springs (87), streams (31), lakes (1), impounding res. (4). 70

supplies have no treatment, 74 disinfection; 42 with some type of further purification treatment. Monthly bacterial samples and weekly or mo. operation reports submitted to state; of 200 bacterial samples submitted in '37–'38, 16 (8.2%) were contaminated, of 195 in '38–'39, 17 (8.7%). Major improvements listed. Special study being made to obtain data on corrosive characteristics of water, especially applicable to west Tenn.—*Martin E. Flentje.*

Court Decision on Public Health. *Compensation Under Workmen's Compensation Act Awarded for Typhoid Fever. Babertz* v. *Township of Hillside* (N. J. Supreme Ct.; 15 A.2nd 796; decided 10-18-40). Pub. Health. Rpts. **55:** 2326 (Dec. 13, '40). Sewer inspector for Hillside Twp., making routine inspection, found sewer clogged and descended manhole to repair. Slipped on step, spattering face and mouth with sewage. Within incubation period, he developed virulent attack of typhoid fever. Sought, and N. J. Supreme Ct. granted, compensation under workmen's compensation act.—*Ralph E. Noble.*

Bureau of Sanitary Engineering, Maryland State Dept. of Health. *Annual Report.* GEORGE L. HALL. ('40). Activities of Bureau in fields of water supply, sewage disposal, industrial waste treatment, mine sealing, stream pollution, industrial hygiene and oyster sanitation described. New works and extensions to existing facilities outlined and brief details given of specific local problems dealt with during yr. Total value of work represented by plans submitted for review approx. $6,862,000. Now 164 public water supply systems and 89 water treatment plants. 110 sewerage systems serve 66.2% of pop. and 78 treatment plants purify sewage from 60.2% of pop. New low record for typhoid fever incidence achieved, case and death rates being 7.0 and 0.5 per 100,000, respectively. Complaint received from property owner residing downstream from Linganore water filtration plant of Frederick, stating that 2 horses died after drinking water from tributary of Lingamore Creek which receives waste waters (backwash water containing small quantities of chlorine and alumina floc) from filter plant. Animals also drank water from old mill race which at times contains excessive algae growths—more probable cause of death.—*R. E. Thompson.*

How Sanitary Engineers Function in Our Army Organization. ANON. Eng. News-Rec. **126:** 605 (Apr. 24, '41). All matters relating to health in province of camp surgeon, and on his staff are one or more Sanitary Corps engrs. In general, Sanitary Corps officer serves as engr.-adviser to camp surgeon, who is responsible for recommending measures necessary for protection of health. Commander of post, camp or fort responsible for ordering that these measures be carried out. Duties of Corps relate to water supply, sewage disposal, mosquito control, refuse disposal, insect control and swimming pools. On Mar. 1, 475 members of Sanitary Corps, 125 being classified as engrs. and 180 as lab. assts. Successful applicants for admission to Corps commissioned immediately as first lieutenants. Activities of Corps under direction of Col. W. A. Hardenbergh. —*R. E. Thompson.*

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